THE NORBY SITE:
A MUMMY CAVE COMPLEX BISON KILL ON THE NORTHERN PLAINS

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ABSTRACT

In the summer of 1988, a Mummy Cave Complex bison kill site, was discovered on Avenue M South, Saskatoon, Saskatchewan. It was subsequently radiocarbon dated to about 5800 BP which placed the site within the Early Middle Prehistoric Period to the time of the Altithermal climatic interval. At one time, researchers thought that the Plains region was abandoned during the Altithermal as a direct result of extreme drought conditions. The results of this study, however, attest to human occupation of the Plains during this climatic interval, especially along major water courses. It is also suggests that subsistence patterns, and bison procurement in general, did not change from that of the previous time period.

Details of the discovery, excavation and analytical techniques applied at the Norby site are presented. The analysis of lithic materials indicates that two projectile point styles are present at the Norby site. The first are side-notched projectile points typical of this time period and the second is a stemmed projectile point, termed a "Manitoba" point. Some "Manitoba" projectile points, discovered in surface sites, were previously associated with Paleoindian assemblages of about 8000 years ago, but the in situ discovery at the Norby site suggests that this projectile point style may have a somewhat later temporal span.

Faunal remains are studied in terms of attritional factors, element counts and distribution, and the sexing and aging of skeletal remains. The role of various taphonomic processes in the destruction and distribution of elements at the Norby site is discussed. Bison population dynamics and bison procurement are discussed in an effort to define the subsistence patterns and practices of the Norby site occupants. This type of information has not been abundant for the interval represented by the Early Middle Prehistoric period.

ACKNOWLEDGEMENTS

Successful completion of the Norby site project required the help and cooperation of several individuals and organizations.

First, special mention must go to Les Norby whose interest in archaeology and preservation of the past brought the site to the attention of the University of Saskatchewan. His ensuing patience, along with that of Vera Norby and Darryl McDonald, made excavation of the Norby site possible. Their complete cooperation was greatly appreciated.

Excavation of the site was carried out by participants of the University of Saskatchewan's Anthropology 260.3 archaeological field school; the principal, Max Abraham, and the grades seven and eight students from King George Elementary School; members of the Saskatoon Archaeological Society as well as friends and a number of other volunteers. Sheila Mahoney, Grant Clarke, Marcel Corbeil, Belinda Riehl-Fitzsimmons, Arok Wolvengrey, Patrick Heal and Sheila Kelly were especially helpful. Special thanks to Mark Nicholson who not only volunteered a number of hours to excavation but, with help from Don Charabin and equipment donated by George, Nicholson, Franko and Associates Ltd., also completed an engineering survey of the entire Norby excavation area.

The project would also not have been possible without the financial aid received from the Saskatchewan Archaeological Society and the Department of Culture, Multiculturalism and

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I would like to thank Dr. Ernest G. Walker, my graduate advisor at the University of Saskatchewan. His organizational skills, ideas and support during the Norby site excavations will not be forgotten. Special thanks also to my thesis committee of Dr. Ernest Walker, Dr. David Meyer and Dr. Urve Linnamae. Their many suggestions regarding the editing of my thesis were greatly appreciated.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES TABLES

LIST OF APPENDICES FIGURES

CHAPTER ONE

INTRODUCTION

The Norby site, FbNp-56, is a bison kill site located on an ancient terrace of the South Saskatchewan River within the city of Saskatoon, Saskatchewan. It was discovered in 1988 by Les Norby during the excavation of a basement beneath his home on Avenue M South. The site was intensively excavated in the summer of 1989 by the Department of Anthropology and Archaeology at the University of Saskatchewan. Three radiocarbon dates clustering around 5800 BP place the site well within the Early Middle Prehistoric (Early Plains Archaic) period; more specifically, it dates to the time of the Altithermal climatic interval (Antevs 1955). Two Mummy Cave complex early side-notched projectile points recovered during site excavations provide additional support for the accuracy of the radiocarbon dates.

The purpose of this thesis, and the analysis of the Norby site assemblage in general, is threefold. First, a review of the climatic literature for the time period 7500 to 5000 BP is presented and related to theories regarding the occupation of the Plains area during the dry Altithermal interval. The fact that the Altithermal period was a time of warming and drying is not disputed in this study. However, theories regarding a climatically-induced abandonment of the Plains region during this particular time are most definitely questioned. The location of the Norby site and its depth of burial provide evidence which can be added to growing amounts of data that serve to disprove theories of Plains abandonment. The Norby site attests to human occupation on the Plains during the Early Middle Prehistoric period, especially along major river course like that of the South Saskatchewan River.

Second, the recovered lithic and faunal assemblages are analyzed in an effort to comment on cultural activities that occurred at the site. The discussion of lithic materials also serves to place the site within the prehistoric cultural chronology of southern Saskatchewan.

Third, a detailed sexing and aging analysis has been carried out in an attempt to determine the type of kill (catastrophic versus attritional), the population structure of the kill assemblage and the method of procurement utilized at the Norby site. This type of information offers some insight into a period of Plains bison hunting which is relatively poorly known and will hopefully add to our understanding of prehistoric subsistence patterns in Saskatchewan during the

Early Middle Prehistoric period.

It is with these goals in mind that the analysis of the Norby site is presented. Chapter 2 provides a detailed description of the modern biophysical environment including both flora and fauna. This serves as a background against which the prehistoric activities of the Norby site are reconstructed. However, since the time period during which the site was occupied is thought to have been warmer and drier than at present, additional climatic evidence is supplied in chapter 3. The dry climatic interval of 7500 to 5000 BP, known as the Altithermal, is discussed in relation to various theories regarding occupation, or lack thereof, of the Plains. Chapter 3 also provides a short discussion of the Mummy Cave complex and the numerous projectile point styles which characterize this period. Such information is useful in establishing a cultural/temporal framework within which the Norby site can be examined.

Chapter 4 is an outline of the research design, excavation procedures and analytical techniques employed at the Norby site. Chapter 5 provides the description of all the lithic artifacts recovered during excavation while chapter 6 presents a detailed analysis of faunal remains. The last chapter of this thesis summarizes the results of the Norby site project and comments on the contributions made by the site to our overall understanding of Plains prehistory.

CHAPTER TWO

BIOPHYSICAL ENVIRONMENT

2.1 Site Location

The Norby site is situated within the city of Saskatoon, Saskatchewan. It is located in the SW SW quarter of Section 29, Township 36, Range 5, west of the 3rd meridian. More specifically, it spans the backyards of residences on 925 (Plan FD, Block 9, Lot north half 5 and all 6) and 927 Avenue M South (Plan FD, Block 9, Lot 4 and south half of 5) in the Riversdale area (Figure 1).

2.2 Site Physiography

The Norby site was discovered in May, 1988 by Les Norby when he reported an intact bone level present in all four walls of a newly dug basement excavation. Initial test pit excavation revealed that there was in fact a concentrated level of bone approximately one metre from the surface and that this bone bed was laterally extensive. In the months of

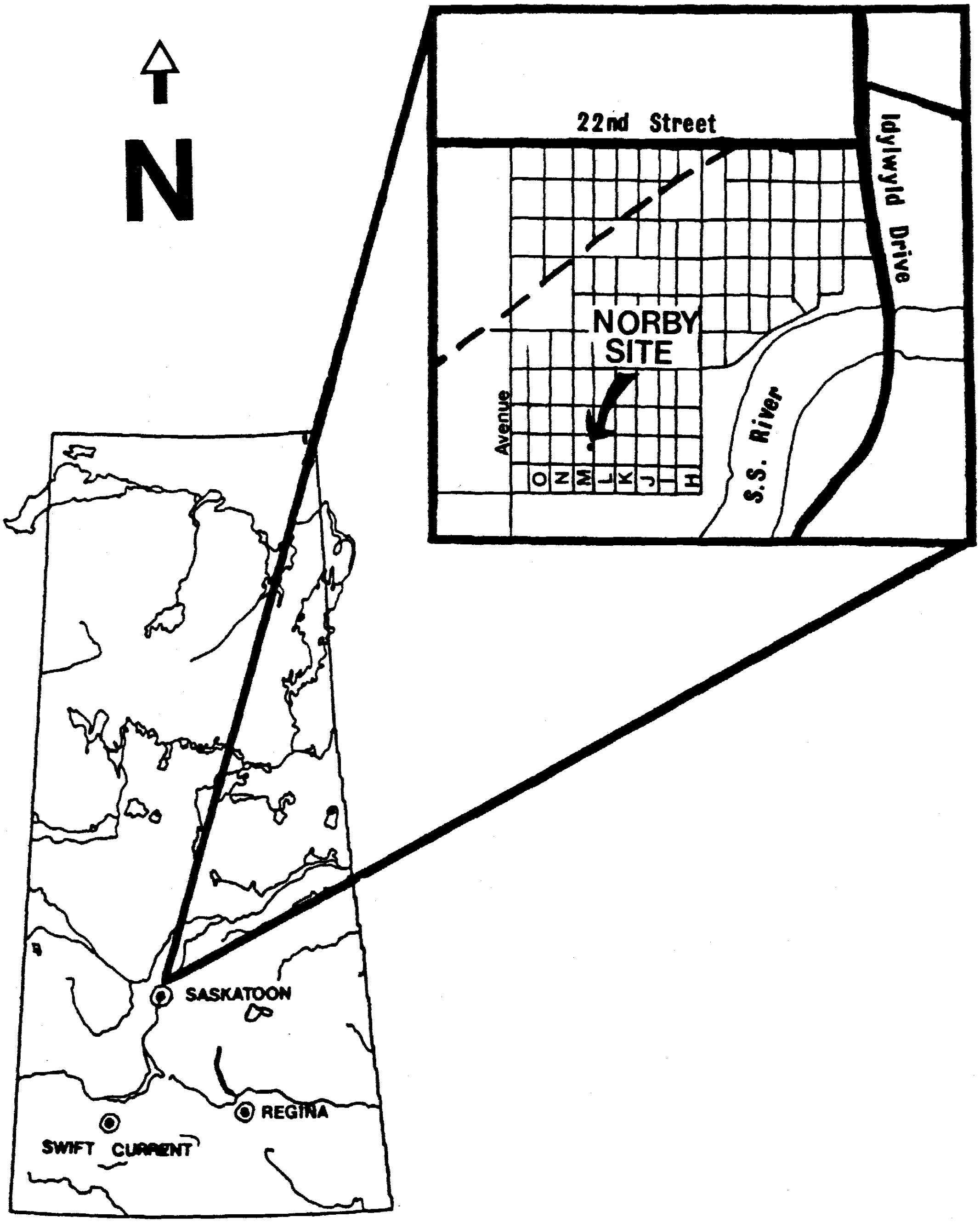


FIGURE 1 Location of the Norby site within the city of Saskatoon, Saskatchewan.

September and October of 1988, a four-square-meter test excavation uncovered a large sample of bone, including intact butchering units. However, no diagnostic artifacts were recovered. A radiocarbon date of 5885 $\pm$ 265 BP (S-3006) was obtained on a sample of the bison bone from the test excavations. The date placed the Norby Site well within the Early Middle Prehistoric period, making it contemporary with two other Mummy Cave complex occupation sites in the Saskatoon area, Gowen I and Gowen II (See Walker 1980, 1987, 1988). In addition to being approximately the same age, the Norby site and the Gowen sites were also located on the same prehistoric landform known as the Saskatoon Terrace.

Prior to 7000 BP the South Saskatchewan River was a braided system. However, after this time several climatic changes caused the river south of the city to begin meandering across a broad floodplain known as Moose Woods Flats. In contrast, the northern portion of the river ran in a linear fashion and came to be deeply incised (Figure 2). The result of this incision was the formation of the prominent Saskatoon Terrace which, subsequently, was occupied by prehistoric peoples. Walker (1980) provides a detailed explanation of the geological formation of the South Saskatchewan River valley as well as a granulometric, palynological and pedological analysis of the Saskatoon Terrace.

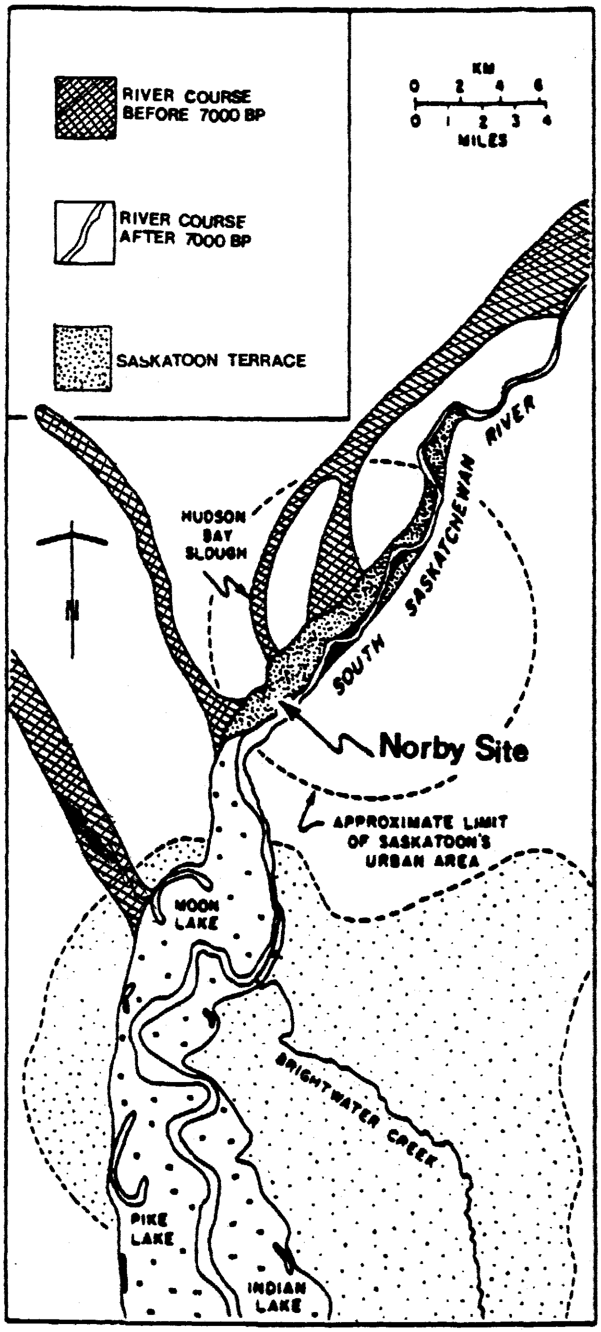


FIGURE 2 South Saskatchewan River course before and after 7000 BP. Note the location of the Saskatoon Terrace (Revised from Walker1980).

2.3 Climate

The modern climatic regime for the Saskatoon region is labelled Dfb in the Koppen-Geiger system of climatic classification (Chakravarti 1969). It consists of a cold, sub-humid continental climate characterized by cold winters and cool summers. January temperatures range from a minimum of ca. -37 °C to a maximum of -6 °C, with a mean temperature of -17.3 °C. Similarly, July temperatures for the same recording period range from a minimum of 5 °C to a maximum of 33 °C or more. The mean temperature for July is approximately 19.1°C (Bergsteinsson and Calvert 1977). These temperatures are slightly lower than those that are thought to have characterized the period between 7000 and 5000 BP. A study, conducted by Kutzbach and Guetter (1982), found that, around 6000 BP, temperatures for July were 1.3 °C more than at present while January temperatures were 0.6 °C less than at present. Mean annual surface temperatures, however, were almost the same or slightly cooler than they are today (Bryson 1987).

The mean annual precipitation for this type of climate is between 350 mm and 400 mm. This includes a mean annual snowfall of 1010 mm to 1140 mm (100 mm of snow is equivalent to 10 mm of rain). The months of June and July see the greatest rainfall, with 70 percent of moisture falling between May and September (Chakravarti 1969). Modern precipitation figures vary slightly from those suggested for the period around 6000 BP; estimates are +0.6 and -0.03/day for July and

January respectively (Kutzbach and Geutter 1982).

2.4 Modern Flora and Fauna

The study area is located on the southern boundary of an area known as the Aspen Parkland Ecotone. This ecotone, which varies in width from 30 km to 60 km and extends from central Alberta to northern Minnesota (Bird 1961), represents a transitional zone between the coniferous forests to the north and the mixed prairie grasslands to the south. The Aspen Parkland ecotone is characterized by two major plant communities, aspen groves and grasslands. Although the Norby site is presently situated within an urban setting, grassland communities predominate the areas immediately surrounding the site. Aspen groves, on the other hand, appear only as isolated patches in regions of suitable topography and soil moisture conditions.

In each plant community there are several nonedible as well as edible species. The following discussion includes only those edible species that were undoubtedly exploited, at least to some extent, by prehistoric peoples - including those who occupied the Norby site.

The following description of the vegetation zones surrounding the Norby site follows that of Walker (1980). Three vegetation zones can be delineated in the immediate vicinity of the Norby site; the Upland Prairie Zone, the Valley Slope Zone and the Floodplain Zone. The Upland Prairie

Zone is dominated by the native grass complex, with speargrass (Stipa comata) and northern wheatgrass (Agropyron dasystachyum) being most abundant. Several subdominant species are present as well, including green needle grass (Stipa viridula), porcupine grass (Stipa spartea) and june grass (Koleria cristata) to mention a few. Forbs, such as pasture sage (Artimisia frigida) and prairie cinqfoil (Potentilla pensylvanica) for example, can also be found on warm southern slopes in this area.

A second plant community in the Upland Prairie Zone, known as the Aspen complex, is restricted to areas such as depressions where moister conditions are available. Vegetation here could include such species as Saskatoon berry (Amelancher alnifolia), willow (Salix sp.), silverberry (Potentilla anserina), western snowberry (Symphoricarpos occidentalis) and prairie rose (Rosa acicularis).

The proximity of the South Saskatchewan River--both at the present time and in the past--in relation to the Norby site warrants the accessibility of riverine resources of the Valley Slope Zone. The distribution of the three major plant community types making up this zone relates directly to the degree to which the river influences them. Stable valley slopes, for instance, possess species of the Mixed Deciduous Tree/Shrub Association and the Poplar/Shrub Association. The overstory component usually consists of a number of tree species including Manitoba maple (Acer negundo), white birch

(Betula papyrifera) and poplars (Populus sp.) while the understory component includes bearberry (Arctostaphylos uva-ursi), low juniper (Juniperus communis), gooseberry (Ribes sp.) and sparsely distributed herbs such as nodding wild rye (Elymus canadensis) and horsetail (Equisetum arvense). In contrast, unstable slopes and areas of active slumping have vegetation much like that found on the uplands. These areas are dominated by Mixed Grass/Shrub Association species such as wild barley (Hordeum jubatum), goldenrod (Solidago sp.) and creeping juniper (Juniperus horizontalis).

Occupying the lowland areas surrounding the Norby site are plant species of the Floodplain Zone, the distribution of which is dependent on the periodic presence of flood water. For example, red osier dogwood (Cornus stolonifera), various willows (Salix sp.) and silverberry (Elaeagnus commutata) can be found immediately bordering the river and creek channels. Vegetation of the Marsh/Channel Association, such as water sedge (Carex aquatilis), cattail (Typha latifolia), early blue violet (Viola adunca), water parsnip (Sium suave) and marsh marigold (Caltha palustris) can also be found but are dependent on the quantities of water available.

The fauna in the immediate vicinity of the Norby site is markedly different from that which existed in the area in prehistoric times. Comprehensive lists of mammalian species which are presently or have formerly inhabited the region are provided by Bird (1961), Beck (1958) and Walker (1980).

Bison (Bison sp.) were the dominant species of the grassland and therefore heavily utilized by prehistoric peoples prior to the historic period. Pronghorn, mule deer and elk were also common, but white-tailed deer (Odocoileus virginianus) is the only species of artiodactyl that still inhabits the area. Carnivorous animals which formerly inhabited these areas included wolf, swift fox, mountain lion, and grizzly bear. Today only coyote (Canis latrans), skunk (Mephitis mephitis), raccoon (Procyon lotor), red fox (Vulpes vulpes), mink (Mustela vison) and weasel (Mustela sp.) are present. Rodents such as the jack rabbit (Lepus townsendii) and snowshoe hare (Lepus borealis) as well as the Least chipmunk (Eutamias minius borealis), northern pocket gopher (Thomomys talpoides), Franklin's ground squirrel (Spermophilus fanklinii), beaver (Castor canadensis), porcupine (Erethizon dorsatum), muskrat (Ondatra zibethicus) and a variety of mice and voles are also abundant in the region.

Several different kinds of birds, including migratory waterfowl, a variety of song birds and the occasional bird of prey, can be found in the study area. Some of the species are the pelican (Pelicanus sp.), red-tailed hawk (Buteo lineatus), great blue heron (Ardea herodias), great horned owl (Bubo virginianus), crow (Corvus brachyrhynchos), ruffed grouse (Bonasa umbellus), magpie (Pica sp.) and a number of black bird, duck and goose species.

CHAPTER THREE

BACKGROUND INFORMATION

3.1 The Altithermal

The term 'Altithermal' was first introduced into the literature by Antevs (1948, 1955) as part of a tripartite model for Holocene climatic change. This scheme was based on the idea of a gradual transition between three climatic periods: a period of warming climate, the Anathermal; maximum warmth, the Altithermal; and cooling climate, the Medithermal. More specifically the Altithermal or 'Long Drought' (Buchner 1980) was defined as a 3500 year interval between 7500 and 4000 BP in which "precipitation was at a minimum and temperature at a maximum" (Schroedl and Walker, 1978:1).

In 1967, Bryson and Wendland challenged Antevs transitional model of climatic change suggesting that the climate changed rapidly, not gradually. Three years later, after a detailed study of radiocarbon dates indicative of climatically significant events, it was concluded that:

> ... a series of quasi-stable climatic episodes separated by rather rapid transitions is a better working hypothesis [for Holocene climatic change] than that of a steady post-glacial rise of temperature to an 'optimum' followed by a steady decline (Bryson et al. 1970: 72).

Bryson and Wendland then recommended that a modified version of Europe's Blytt-Sernander terminology for climatic episodes be adopted to label each period of climatic change in North America. Seven periods, set out in 1978 by Wendland, were as follows: Late Glacial (until ca. 10030 BP), Pre-Boreal (ca. 10030 to 9300 BP), Boreal (ca. 9300 to 8490 BP), Atlantic (ca. 8490 to 5060 BP), Sub-Boreal (ca. 5060 to 2760 BP) and Sub-Atlantic (ca. 2760 to present). The greatest virtue of this nomenclature was that it did not carry with it any predetermined assumptions of the climatic character of each episode (Bryson 1987: 1).

The Blytt-Sernander climatic scheme gathered wide acceptance and support in North America, particularly in the archaeological realm (eg. Bryson 1974, 1987; Frison 1975; Frison et al. 1978; Keuhn et al. 1987; Reeves 1973; Wendland 1980), replacing the old views of gradual climatic change. Even though Antevs' model of transitional change had been disproved, the terminology he had introduced remained entrenched in the literature (Walker 1980). Instead of representing a geochronological period, however, the Altithermal came to serve another purpose, one specifically archaeological. Because the Altithermal had been described as a period of aridity and, therefore, environmental crisis, it began to be used as a quick explanation for any changes that occurred in the archaeological record during the Holocene (Schweger 1987: 372-373). Rather that leading to abandonment, however, the episodic nature of the Altithermal climate may, in fact, have allowed for a continuous occupation of the Northern Plains.

3.2 Theories on Plains Abandonment

Mulloy (1958) was the first in a long line of researchers to note a lack of archaeological sites on the Plains that dated to the Altithermal Period. When he formulated a cultural chronology for the Northwestern Plains region, he chose not to name the period between 7500 and 5000 BP suggesting that the Plains may have been abandoned at this time due to adverse climatic conditions. It has since been noted by several authors (eg. Frison 1975; Reeves 1973; Walker 1980) that Mulloy originally emphasized the fact that this was only an hypothesis and that the absence of recorded archaeological sites may have been a result of insufficient archaeological excavations in the Plains area. Nevertheless, the idea of Plains abandonment, and thus a cultural hiatus, became ingrained in the literature.

An immediate reaction to Mulloy's hypothesis was the formulation of other theories with regard to the idea of Plains abandonment. For instance, Jennings' (1964), feeling that the Altithermal had not been any drier than any other climatic period, proposed that a developed culture, pre-adapted to dry conditions, moved out onto the Plains from the Great Basin between 7500 and 5000 BP (Jennings and Norbeck 1955). This 'Desert Culture' was a "fully exploitive gathering-collecting-hunting scheme involving great mobility and special food gathering techniques" (Jennings 1964: 150). Similarly, Stephenson (1965) supported the idea that there had been Great Basin influences acting on the Plains populations.

In a comparable argument to that of Jennings and Stephenson, Wedel (1961: 214-215) suggested that, not only were people occupying the Plains during the Altithermal, but they were foragers similar to populations in the Great Basin. Although Wedel admitted that abandonment <u>may</u> have occurred, he stated that until there was more proof that the High Plains really did lack hunting-culture sites he would maintain reservations regarding Plains abandonment theories. In a later article, Wedel (1978) revised his theory stating that temperature increase and falling levels of precipitation during the Altithermal led to an abandonment of the Plains and a movement of populations into peripheral areas. This, however, was simply a reiteration of Hurt's 1966 theory which maintained that not all areas of the Plains experienced decreased precipitation between 7000 and 4500 BP and in fact, certain sections would have seen relatively more precipitation and lower evaporation rates than others (Hurt 1966: 110).

These regions, which included the northern periphery, eastern periphery, certain river systems and springs that originated in mountain areas and zones of relatively higher elevation in the western half of the Plains, could then have been used as refuge areas by both man and beast.

Very similar to the ideas of Hurt were those of Frison (1968; 1975; 1978) who felt that "oasis-like" areas, such as the Black Hills (Frison et al. 1978), were occupied during the Altithermal Period. However, he claimed that since the Plains became a desiccated wasteland during the drought and therefore would not have been able to support a viable bison population, people would have been forced to abandon the Plains for moister peripheral mountain or interior mountain regions.

Although supported by many authors, Frison's marginal occupation theory was criticized by some. Reeves (1973), for example, suggested that despite arid conditions and a desiccation of the Central Plains grassland areas, there was not a substantial decrease in prehistoric use of the Plains region during the Altithermal. Instead Reeves offered several alternative explanations for the lack of archaeological evidence supporting Altithermal occupation of the Central Plains (Figure 3). One reason is simply that of skewed sampling; work just has not been carried out in all areas with equal vigour (Reeves 1973; Wendland 1978). Only a very small area of the Plains has been sampled because most archaeologists have relied on salvage work (Walker 1980)

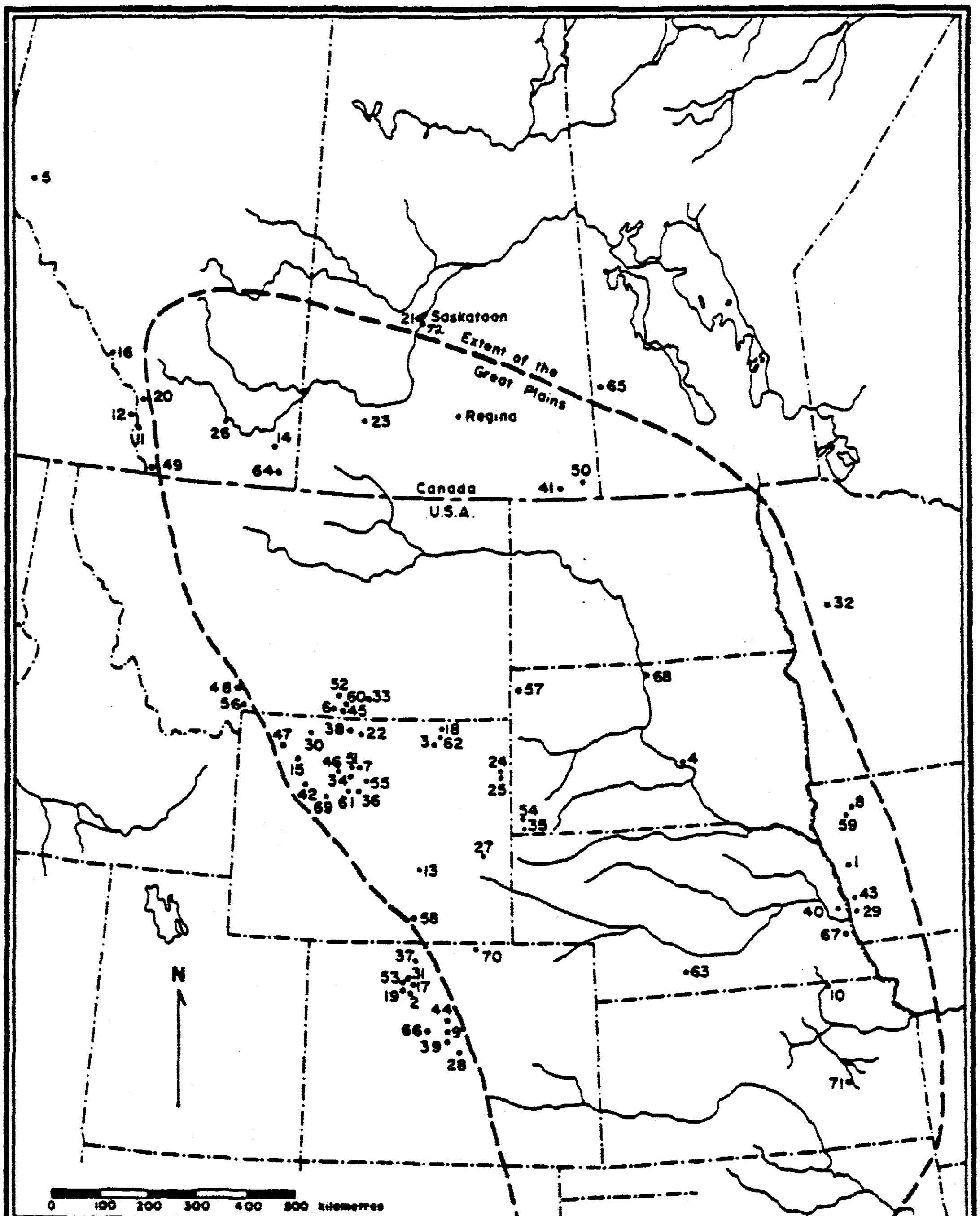


FIGURE 3 Map of sites dating to the Early Middle Prehistoric Period on the Northwestern Plains. Numbers correspond to site names listed in Table 1. (After Walker 1980).

TABLE 1 Early Middle Prehistoric sites of the Northwestern Plains region. (Taken from Walker 1980)

REF. No	SITE NAME	REF. No.	SITE NAME
1	A.C. Banks	38	Little Bald Mountain
2	Albion Boardinghouse	39	LoDaisKa
3	Bentzen-Kaufmann Cave	40	Logan Creek
4	Big Bend Sites	41	Long Creek
5	Boss Hill	42	Lookingbill
6	Bottleneck Cave	43	Lungren
7	Carter Cave	44	Magic Mountain
8	Cherokee Sewer	45	Mangus
9	Cherry Gulch	46	Medicine Lodge Creek
10	Coffey	47	Mummy Cave
11	DjPl-47	48	Myers-Hindman
12	DjPp-8	49	Narrows
13	Dunlap-McMurray	50	Oxbow Dam
14	East Battle Creek	51	Paint Rock V
15	Edgar Cave	52	Pretty Creek
16	EfPs-3	53	Ptarmigan
17	5BL70	54	Ray Long
18	48CK46	55	Rice Cave
19	Fourth-of-July Valley	56	Rigler Bluffs
20	Gap	57	Reva
21	Gowen	58	Shoreline
22	Granite Creek	59	Simonsen
23	Gray	60	Sorensen
24	Hawken I	61	Southsider Cave
25	Hawken III	62	Spanish Point
26	Head-Smashed-In	63	Spring Creek
27	Hell Gap	64	Stampede
28	Helmer Ranch	65	Sawn Valley
29	Hill	66	Vail Pass
31	Hungry Whistler	67	Walker-Gilmore
32	Itasca	68	Walth Bay
33	Kobold	69	Wedding of the Waters
34	Laddie Creek	70	Wilbur Thomas Shelter
35	Lander	71	William Young
36	Leigh Cave	72	Norby
37	Lightning Hill		

and/or the work of people like George Frison in Wyoming, to uncover the sites. As a result, site distribution maps, such as those compiled by Walker (1980) and Buchner (1980), reveal incomplete pictures of site distribution; sites tend to be unevenly concentrated along the east flanks of the Rocky Mountains and outlying mountainous zones (Reeves 1973: 1273).

A second reason for the lack of Altithermal sites is their geographical location. Since most of the sites dating to this time period were located on river terraces and floodplains, they have been directly affected by subsequent periods of alluvial deposition and degradation. The character of the paleohydrological sequence, therefore, "destroyed or deeply buried the emergent floodplain surfaces which existed during the interval 5500 - 3000 BC" (Reeves 1973:1243). Evidence is accumulating to support this hypothesis in the form of numerous deeply buried sites. These sites include Walth Bay (Ahler 1974), Head-Smashed-In (Reeves 1978), Gowen I (Walker 1980), Gowen II (Walker 1990, pers. com.) and now the Norby site, which is buried under more than a metre of sandy overburden.

Reeves (1973: 1246) also suggested that many archaeologists have failed to recognize projectile points from the Altithermal period due to their similarity to the later side-notched points such as the Besant or Hanna projectile point styles. Greiser (1985: 89) agreed with Reeves on this point noting that, because the antiquity of side-notched points has been only recently recognized, "pertinent sites were probably misrecorded in the states' archaeological files."

A final reason for a lack of Altithermal information lies in the fact that most of the contemporary landforms that would have been preferred sites of occupation by Middle Prehistoric peoples, especially river terraces, are not of sufficient age on the Plains to have been occupied during the Altithermal. The Saskatoon Terrace, on which the Norby Site, Gowen I and Gowen II are situated, could only be occupied after 7000 BP. Since such landforms are older in mountainous regions, sites are more common in these areas (Reeves 1973: 1243).

That the Altithermal was a time of decreased precipitation has been supported by numerous ecological studies (eg. Anderson and Semken, Jr. 1978; Baerreis 1980; Baker and Van Zant 1980; Root and Ahler 1987; Semken 1980; and Tatum 1980) and is not a point to be argued here. However, opinions concerning cultural change, especially changes in subsistence strategy, and how these relate to the climatic conditions of the time, are extremely diverse. Numerous authors have maintained that climatic change does not necessarily lead to cultural change (eg. Benedict and Olson 1978; Schweger 1987). Nevertheless, studies such as that completed by Bryson (1978) on radiocarbon dates of both ecological and cultural events tend to suggest that cultural change closely relates to environmentally induced botanical changes. Similarly, Frison (1975, 1978) states that Altithermal cultures had to adjust to adverse climatic conditions by concentrating on a forager subsistence rather that one dominated by hunting of large game animals. This point is also supported by Madsen and Berry (1975), who stress that Early Middle Prehistoric settlement and subsistence patterns did not change, from earlier Paleoindian patterns, due to decreases in forage yield, and by Greiser (1985) who feels that a reduction in resource abundance led hunters and gatherers to follow a mixed-strategy subsistence pattern.

In contrast, Reeves (1978) contends that, based on evidence from the Head-Smashed-In excavations in Alberta, communal bison procurement continued as the major subsistence strategy throughout the Altithermal (Walker 1980: 137). Reeves' arguments are supported by numerous studies including Itasca (Shay 1978), DlPo-20 (Reeves and Dormarr 1972), Simonsen (Frankforter and Agogino 1959) and Mummy Cave (McCracken et al. 1968) to name a few. Buchner (1980: 159; emphasis added), in support of Reeves, notes that the only difference between assemblages of Paleoindian and those of Middle Period populations on the western Plains was the change in point style; <u>everything</u> else, including subsistence strategies, was similar. Evidence from the Hawken Site (Frison et al. 1976) and now from the Norby site also support a continuum of subsistence strategies. These sites however, are in areas described by Frison (1978) as "oasis-like".

Overall, recent studies and accumulating evidence seem to support at least sporadic, if not continuous occupation of the Plains regions during the Altithermal (Walker 1980, 1987, 1988). As to the relationship between climatic and cultural change, the most reasonable statement is presented by Benedict and Olson (1978: 176; original emphasis) who state that "the link between climate changes and human population response is variable in time and space depending on <u>which</u> climatic factors, if any, were limiting human survival." In other words, cultural change was undoubtedly variable between regions and between time periods.

3.2 The Mummy Cave Cultural Complex

Relatively little is known about the various styles of side-notched projectile points that date to the Early Middle Prehistoric Period. As a result, terms that have been employed by authors in their attempts to describe or delineate cultural assemblages of this time are not always consistent. Consequently, some confusion over the nomenclature exists.

The term Mummy Cave complex was first proposed by Reeves (1973). It encompasses those site assemblages in the Northwestern Plains and Rocky Mountain regions that are characterized by projectile points classified as Bitterroot (Swanson 1962) and/or Salmon River Side-notched. Such point styles also seem to characterize assemblages from the

Northeastern periphery such as that from the Itasca Site (Shay 1978) and the Swan River Site (Gryba 1968). The Bitterroot point style is thought to have developed either in Idaho, or evolved out of related Great Basin styles (Swanson and Sneed 1966, as cited in Epp and Dyck 1983: 92).

In contrast to Reeve's ideas, Buchner (1980: 144-154) discusses a Mummy Cave point style--evidenced by levels 19 to 23 at Mummy Cave, lower levels at Kobold, level 3 at Bentzen-Kaufmann Cave and the Gap Site--as one of the main components of the Mummy Cave complex. He acknowledges the similarities, and undoubtedly the relationship, between Mummy Cave projectile points and the Bitterroot and Salmon River Side-notched points but keeps these latter two point styles separate and geographically isolated to sites in Idaho. It should be noted here that Buchner neglects to define or describe a "Mummy Cave Side-notched" point and therefore reference to such a point style remains unwarranted.

Related to the Bitterroot Side-notched projectile point type, but earlier in time and geographically restricted to the Central Plains, are the cultural assemblages containing Simonsen Side-notched points. Reeves (1973: 1244) hypothesized that Bitterroot diffused out of this earlier Central Plains culture which, in turn, ultimately arose out of eastern Plains cultures. Similarly Buchner (1980), who has grouped the Simonsen points with Logan Creek Side-notched styles into what has been termed the Logan Creek complex, also sees the eastern periphery as the origin for side-notched projectile points on the Plains. It has also been suggested that the origin for the Mummy Cave complex lies to the southwest (Walker, pers. com. 1990) or in a combination of southwest and eastern influences.

Another second western complex has been termed the Mount Albion complex (Benedict and Olson 1978). The majority of these sites are located near the present timberline and are characterized by points that are either side- or corner-notched. Despite its dating to the Early Middle Prehistoric period, Mount Albion assemblages are considered by most archaeologists as culturally distinct from the other cultural complexes present on the Plains (Buchner 1980). However, some are opposed to this view. For example, Benedict (1981: 113) sees the Albion point style as,

> ... part of an archaeological continuum that existed, during the Altithermal, across much of the northern United States and southern Canada, from the Columbia Plateau and northern Great Basin (Bitterroot Side-Notched, Northern Side-Notched and Elko Side-Notched points) through the Central and Northern Rocky Mountains (Mummy Cave Side-Notched points) to the Central Plains and Prairie Peninsula (Logan Creek and Simonsen Side-Notched points).

As one reviews the literature, it becomes increasingly apparent that the subjective criteria used to classify site assemblages has resulted in discrepancies as to which complexes include which point styles and which point styles, if any, have any statistical basis. In an attempt to at least designate point types, a sample of projectile points from various regions throughout the Plains has recently been subjected to a discriminant analysis (Schroedl n.d. as cited in Walker 1980). The analysis was patterned after that employed by Holmer (1978) in his original attempts to derive a point typology for the Eastern Great Basin. Although Walker (1980:158) asserts that the resulting combinations are tentative at best and therefore would require further statistical studies to designate possible relationships to the preceding, contemporary and succeeding cultural assemblage, such a statistical technique would undoubtedly lessen the degree of subjectivity that has plagued projectile point typologies from their very beginnings.

Walker (1980:157-176) distinguishes five point types:

1) Blackwater Side-notched points are the oldest style dating between 7600 and 7200 BP. This point style is evidenced at Mummy Cave and the Stampede Site.

2) Northern (Bitterroot) Side-notched have a distinctive high side-notch and tend to be radiocarbon dated between 7200 and 6700 BP. They are found at Mummy Cave, Stampede Site and the Lookingbill Site.

3) Hawken Side-notched points, found at the Hawken Site and at Mummy Cave, date between 6500 and 5300 BP.

4) Gowen Side-notched, which may be synonymous with Salmon River points, are relatively non-descript and date between 6000 and 5200 BP.

5) Mount Albion Corner-notched, common on the Colorado Front range, are the most recent dating between 5700 and 4500 BP.

Where the Norby site projectile points fit into Walker's (1980) scheme is relatively clear. Although the size of the

Norby site sample, with only six complete projectile points, is severely limited, three of the side-notched projectile points have been classified as Gowen Side-notched. However, the presence of a stemmed projectile point serves to confuse the issue. This stemmed specimen appears to be a heavily reworked "Manitoba" point. The "Manitoba" projectile point style, its age and relationship to the Norby site projectile points will be discussed in a later section of this thesis.

CHAPTER FOUR

RESEARCH DESIGN AND METHODOLOGY

4.1 Discovery and Test Excavation

The Norby site was discovered in May, 1988 when Les Norby began renovations on the basement beneath his home on Avenue M South. He discovered a large amount of bone coming out in the excavation fill and, realizing the possible importance of such a find, immediately contacted Dr. Ernest Walker at the University of Saskatchewan's Department of Archaeology and Anthropology. When Dr. Walker visited the site he found an intact bone level in all four walls of the basement excavation. Test pits further revealed that the bone bed was laterally extensive. These reasons, as well as the rather old appearance of the bone, prompted Dr. Walker to organize a small test excavation later in the year.

Test excavations were carried out sporadically during September and October, 1988 by Dr. Walker, myself and a small crew of archaeologists from the University of Saskatchewan.

We excavated a total of four square meters to a depth of approximately 120 cm. One unit was shovel tested below the bone bed but no further occupation levels were discovered.

Although a large sample of bone was uncovered during test excavations, no diagnostic artifacts were recovered. A radiocarbon date of 5885 $\pm$ 265 BP (S-3006, Area A test excavation) was obtained on a sample of bison bone from the test excavations in Area A of the site. Since that time two additional bone samples have been submitted, one from unit 22 of Area B and the second from unit 2 of Area C, and subsequently dated to 5740 $\pm$ 110 BP (S-3205, Area B, unit 22) and 5560 $\pm$ 120 BP (S-3206, Area C, unit 1). These dates place the Norby Site well within the Early Middle Prehistoric period, making it roughly contemporary with two other Mummy Cave complex occupation sites in the Saskatoon area, Gowen I and Gowen II (See Walker 1980).

With the preliminary excavations completed and a six thousand year old radiocarbon date in hand, the significance of the Norby site soon became apparent. Consequently, it was decided that an intensive excavation of the area would be carried out the following summer. Neighbours on either side of the Norby residence were promptly contacted and subsequently agreed to allow excavation in their backyards. The project was planned to begin on May 15, 1989.

Before actual excavation could begin, however, it was necessary to determine the boundaries of the site (Figure 4).

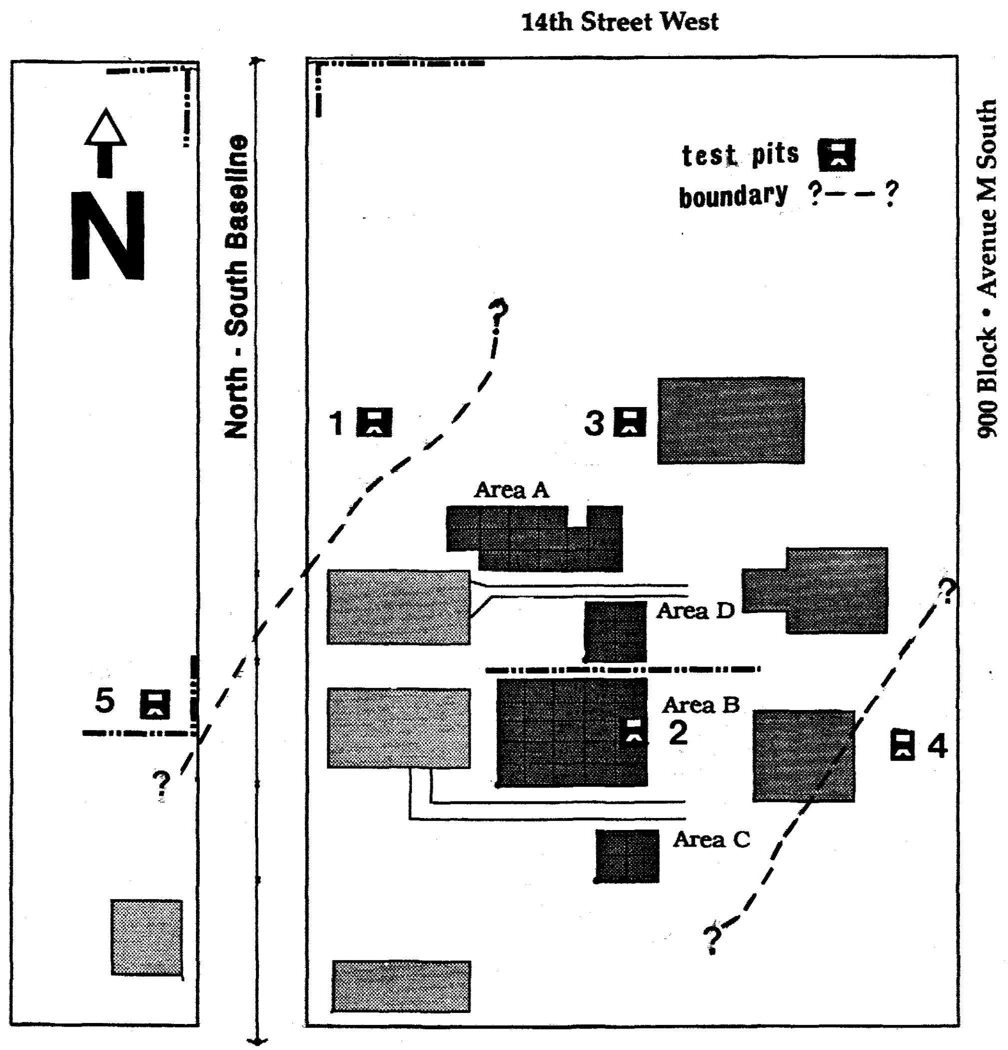


FIGURE 4 Location of the Norby site test pits and the possible northwest and southeast boundaries of the kill.

The southern and northern boundaries of the Norby site were delineated in April 1989 with the excavation of three test pits. Test Pits 1 and 3 in the Boire's yard and garden, which lies to the north of the Norby's home, failed to yield any cultural material. The lack of bone in the third test pit, however, was not too surprising once it was discovered that we were digging in an area that had previously been disturbed by extensive digging. This initial disturbance of the natural stratigraphy of the area probably took place when the basement beneath the Boire house was constructed. Through personal communication with the owner, we do know that a large amount of bone, and even projectile points or tools, were discovered beneath their home as it was in the process of being built in 1975. As a result, it is possible to say that the kill extends in a northeast direction past the Boire house and quite possibly further. Exactly how far the site extends in this direction, though, is not known.

In comparison to other test pits, Test Pit 2, in the yard to the south of the Norby residence, revealed an intact bone bed beginning at a depth of 116 cm. A southern border for the site was never delineated due to the interference created by a city-owned grass boulevard and 12th Street West.

During the last week of August, Test Pit 4 and Test Pit 5 were excavated. Test Pit 4, in the front yard to the south of the Norby residence, was excavated to a depth of 150 cm, but produced only a hard sandy/clay soil with no evidence of cultural activity. The results of Test Pit 5, across the alley from the Norby's, were similar. The stratigraphy in this test pit, however, was identical to that found in the original test excavation areas but, although a darkened soil horizon was encountered, neither bone nor cultural materials were recovered. It was concluded that the site was not as wide in an east-west direction as was originally anticipated. Rather, it seemed to run in a linear, yet convoluted fashion through the area as a whole.

Overall, the site quite possibly covered an area as wide as 70 to 100 metres in a northwest-southeast direction. The length of the site, however, is impossible to determine due to restrictions imposed on the research project by the urban setting.

4.2 Excavation Procedures

After considering the constraints of an urban environment and the results of the test pits, four loci were chosen for excavation: two were in the yard of 927 Avenue M South to the south of the original test excavation; the remaining two areas were in the backyard of 925 Avenue M South. The four areas, consisting of fifty square metres, were set up as follows: Area A contained fifteen one metre- square-units; Area B, twenty-five units; Area C, four units; and Area D, six units (Figure 5).

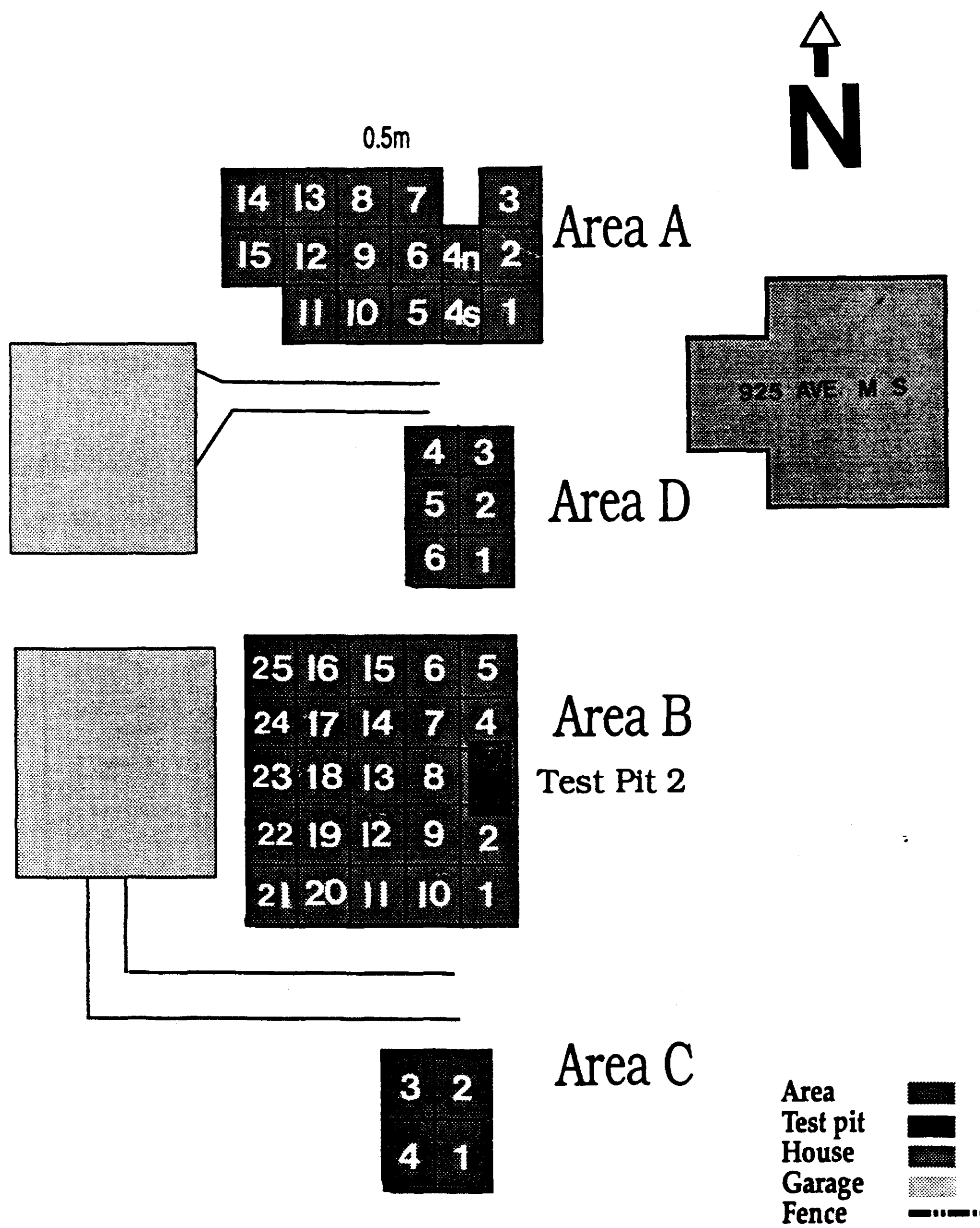


FIGURE 5 Survey map showing the placement, sectioning and numbering of excavation areas.

The location of the Norby Site in the city of Saskatoon provided a unique, although problematic situation within which to organize and carry out an archaeological excavation. One of our first problems involved the exact placement of units for excavation. Although surveying-in excavation units from a set datum point is the typical practice at archaeological sites, space restrictions prevented us from following this procedure. Instead, we were essentially forced to place excavation units wherever we could find room, with each having its own datum on the southwest corner from which vertical measurements could be taken.

The perimeters of four separate excavation areas were measured and marked off with string. An engineering survey was conducted on October 8, 1989 by Mark Nicholson and his assistant Don Charabin, using equipment borrowed from George, Nicholson, Fanko and Associates Ltd, in order to tie in all the southwest corner datums. Elevations for each area were determined using an automatic level and rod. An elevation above sea level was also determined for a point near the site. Horizontal control was established by preparing a north-south baseline along the lane way west of the excavation. Two large spikes were countersunk into the lane near the ends of the block and measurements were made from the south end at points at right angles to the excavation. The excavation areas were then tied in with a transit and measuring tape.

When the survey was complete, it was possible to tie in the corner pegs to a set city datum. In this way all the depth measurements between and within areas could be related and the elevation of each area calculated. In addition to this, however, the survey revealed that the pits had not been placed on a perfectly north-south orientation as was initially intended. Rather, each area was set on a slight angle to the north-south baseline in the lane way. The survey also revealed that, because they were set up independently, the orientation of each excavation area to the other areas also varied (Figure 6). These variations, however, were slight and future problems arising from such discrepancies were not expected.

Actual excavation of the Norby site was initiated on May 15, 1989 by the members of the University of Saskatchewan's Anthropology 260.3 archaeological field school (Figure 7). Once this course had been completed, the grades seven and eight students from King George Elementary School spent three weeks at the site learning the various methods and techniques employed by archaeologists (Figure 8). The remaining months of the summer were spent completing the project at the Norby site. Work during this time was carried out by myself and a number of volunteers who showed up sporadically over the summer to experience actual archaeological excavation.

Excavation of the site was carried out with the intent to collect as much lithic and faunal data as possible so that an overall understanding of site activities could be reached upon

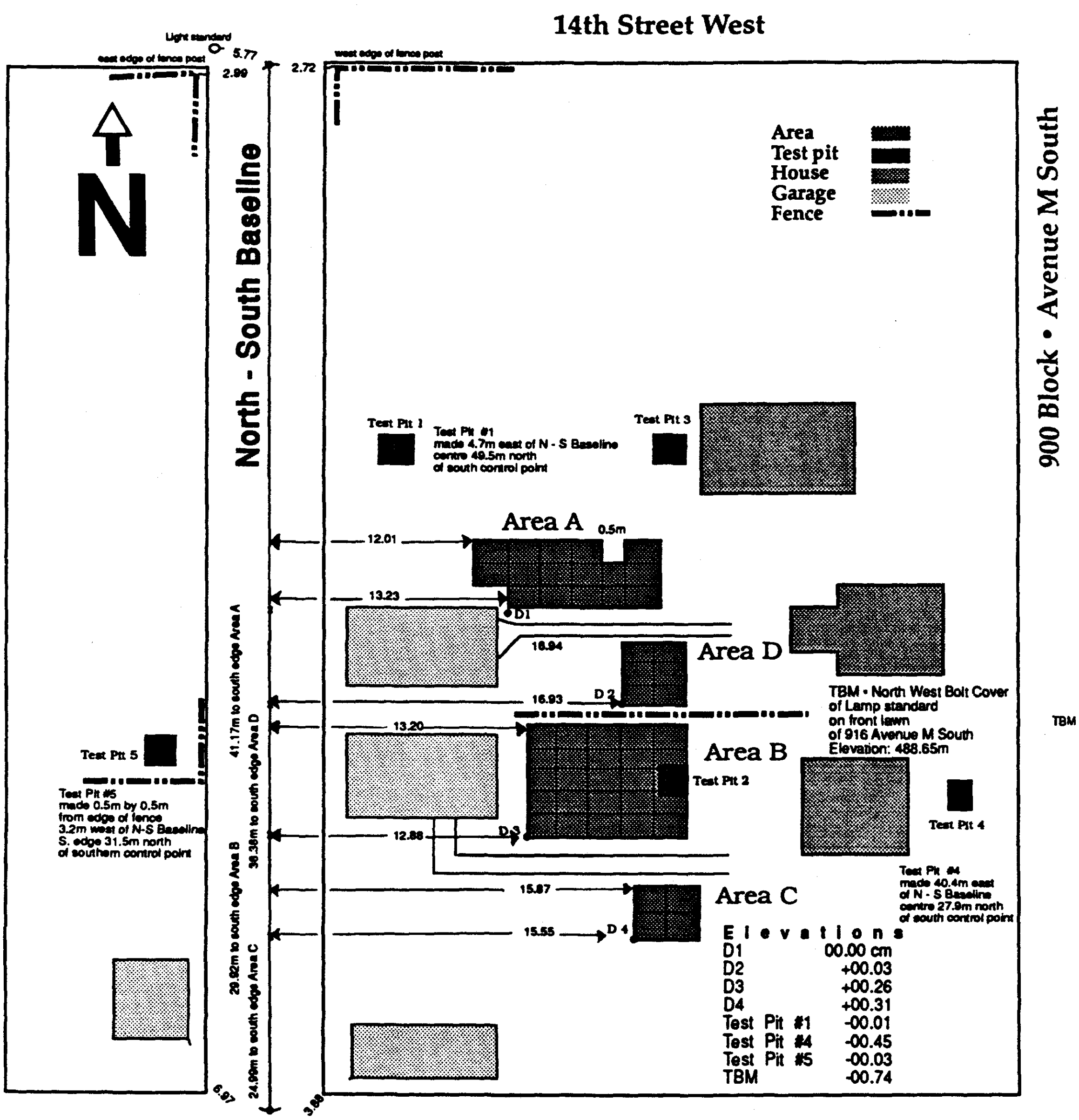


FIGURE 6 Survey map showing measurements and elevations taken at the Norby site. Note also the distances from each area's west corner peg to the north-south baseline in the lane way west of the Norby residence.

FIGURE 7 Students excavating during a University of Saskatchewan archaeological field school.

completion of artifact analysis. The techniques and methodologies employed at the Norby site were designed for the above purpose and were as follows. For each excavation area, the topsoil, which consisted of the top 30 centimetres of soil, was removed with shovels and placed on black plastic for storage. Shovelling continued until a depth of about 80 cm was reached. At this time it became necessary to shovel shave, removing only a few centimetres of matrix at one time. The next 20 cm of sandy soil was put through a 1/4 inch screen. In this way, any small bone and/or lithic fragments that were present in the fill could be collected. It must be notes here

FIGURE 8 King George Elementary School students excavating Area B of the Norby site.

that the amount of overburden and texture of the soil did not allow one to dig down unit by unit and thereby keep the bone and stone fragments between units separate. Rather, all fragments that were collected between the depths of 80 cm and 100 cm were done so for the area as a whole.

Once the top of the bone bed was encountered the exposed area was measured and strung off into one-meter- square units for excavation (Figure 9). Excavation from this point downward was accomplished using trowels, grapefruit knives and paint brushes. Unit number was modified from that employed on maps of the National Topographic Series for township designation (see Figure 5).

As excavation began, the quadrant method, practised at many archaeological sites in Saskatchewan, was employed. This technique however, was quickly abandoned due to its impracticality when dealing with a thick bone bed. Instead, whole units were excavated at one time, taking care to keep each unit's artifacts and bone fragments separate.

Because only one level was present at the Norby site each unit was excavated in arbitrarily defined exposures. At times, when the bone level was extremely thick, two or three exposures were necessary before all the bone could be adequately exposed for photographic purposes. Once it was revealed, the bone in each unit was photographed and mapped using a 20 cm grid system (Figure 10). Both horizontal and vertical provenience measurements were made to the nearest 0.5 centimetre. Each artifact was then given an artifact number, removed, bagged and taken to the Archaeology laboratory at the University of Saskatchewan to be washed and catalogued.

Directly after an area excavation was completed profiles were drawn for all four walls of the pit (Figure 11). At the Norby site profiles were straightforward because there was only one occupation level to contend with (Figure 12). Basically, the top 30 cm of soil, after the topsoil was removed, consisted of a disturbed, mottled zone (Disturbed Zone A). This was sometimes followed by a level of garbage (Disturbed Zone B), dating between the 1920s and 1940s, and then by 30 cm of sterile black/grey sand. Underlying the

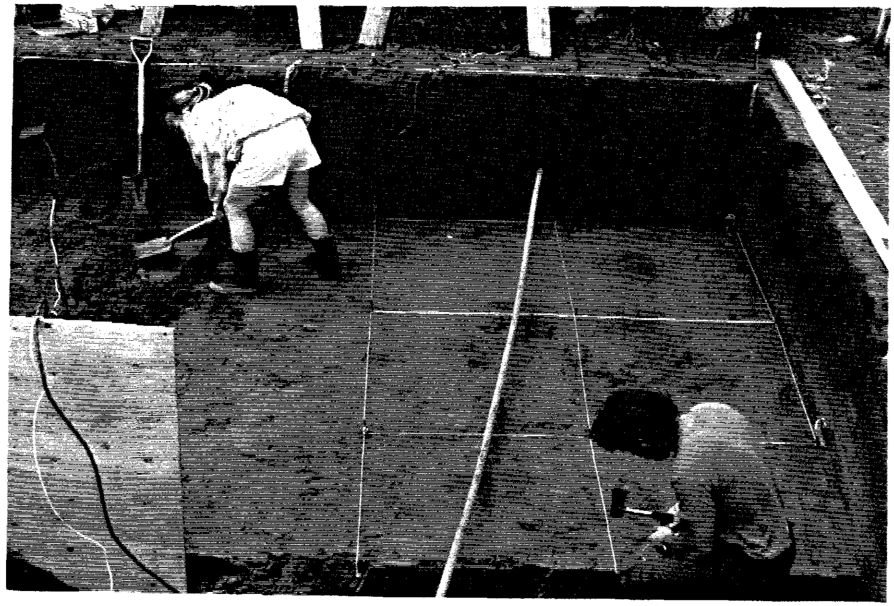


FIGURE 9 Shovel shaving technique and unit boundaries shown.

FIGURE 10 A 20 cm grid was used for recording horizontal provenience through a mapping procedure. Photos were taken for each excavation unit.

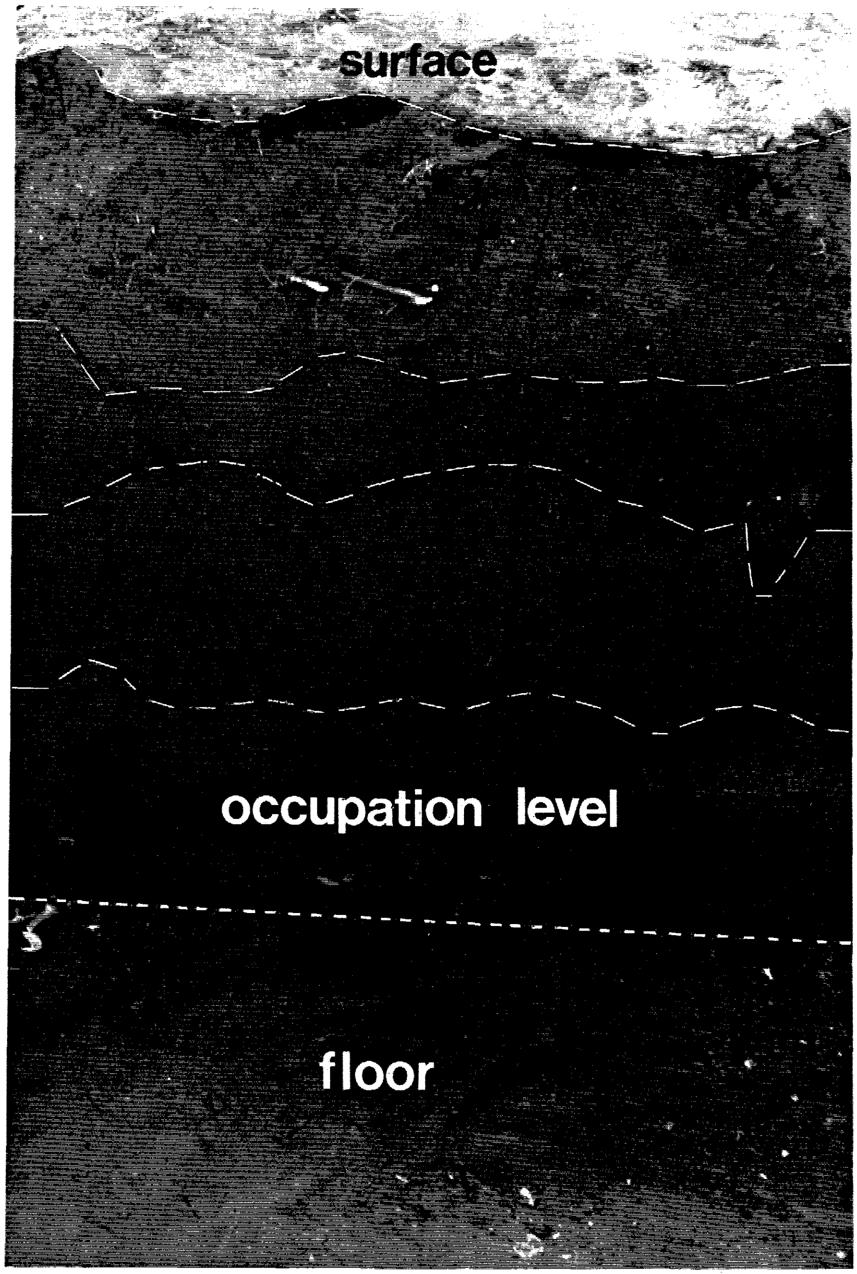


FIGURE 11 West wall profile from Area A excavation.

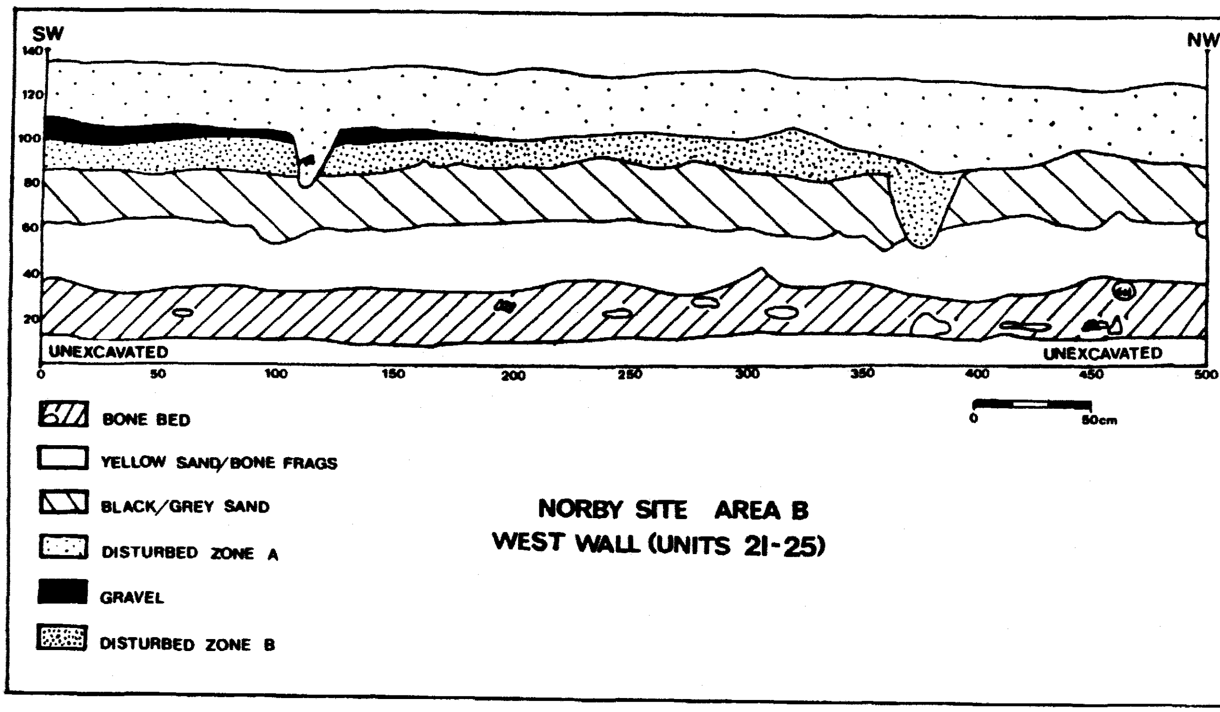


FIGURE 12 West wall profile of Area B excavation.

sterile soil was a 20 cm thick level of golden sand containing very small fragments of bone. At a level averaging about 110 cm below the surface lay the bone bed itself. It varied in thickness but usually ended once a depth of 120-125 cm was reached.

4.3 Analytical Procedures

As mentioned previously, the entire Norby site collection was washed and catalogued by a lab technician at the University of Saskatchewan. Using a Data Base III computer program, artifacts were classified into one of the following five major categories: bone (BON), burned bone (BBN), teeth (TTH), burned teeth (BTH) and lithics (LIT). The lithics were further classified into groups of projectile points (PPT), point preforms (PRF), unifaces (UNF), bifaces (BIF) and debitage (Debitage - DEB; Microdebitage - MDB; Flake - FLK; Microflake - MFK). These, as well as raw materials, are discussed in detail in Chapter 5.

By far the majority of the Norby site artifact assemblage consisted of faunal remains, particularly bison remains. Several attributes were recorded for each skeletal element including field unit number, laboratory catalogue number, material type (Bone - BON; Burned Bone - BBN; Bone and Tooth - B/T; Teeth - THT; Burned Teeth - BTH), form (Fragmented - FRA; Complete - COM; Almost Complete - ACM; Fragments - FGS), species (Bison, Canid, Rodent, or Unknown), skeletal part, side (Left - L; Right -R), quantity and weight. Where possible, elements were also designated as mature or immature. In addition, long bones were further classified with regard to the presence of complete, distal or proximal portions of the element. The presence or absence of epiphyses was also noted.

An analysis involving long bone measurements was carried out in an effort to determine the sex of individual bison specimens. Measurements of anterior 1st phalanx, astragali, calcanei, other carpals and tarsal and metapodials were also taken with the intent to further substantiate the initial population sexing results. A detailed study of both upper and lower bison dentition was also completed in order to establish the seasonality of the kill. All information was then combined in an attempt to reconstruct bison population dynamics, and on bison procurement in general, during the Altithermal climatic interval of the High Plains.

CHAPTER FIVE

NORBY SITE LITHIC ASSEMBLAGE

5.1 Introduction

The lithic sample from the Norby site is small. Only a total of 176 lithic artifacts were recovered from the excavations of which 20 were formed tools. The majority of these artifacts, including formed tools, were recovered from Area B excavations (Figure 13). This may be a reflection of the overall size of the areal excavations rather than the degree of cultural activity; Area B consists of twenty-five square meters of excavation while Area A, C and D are fifteen, four and six square meters respectively.

The tools recovered at the site have been classified into standard categories employed in archaeological descriptions, including projectile points, preforms, bifacial tools, unifacial tools and anvils/hammerstones. The remainder of the assemblage is overwhelmingly dominated by unmodified flakes and tiny retouch flakes. These have been identified as core

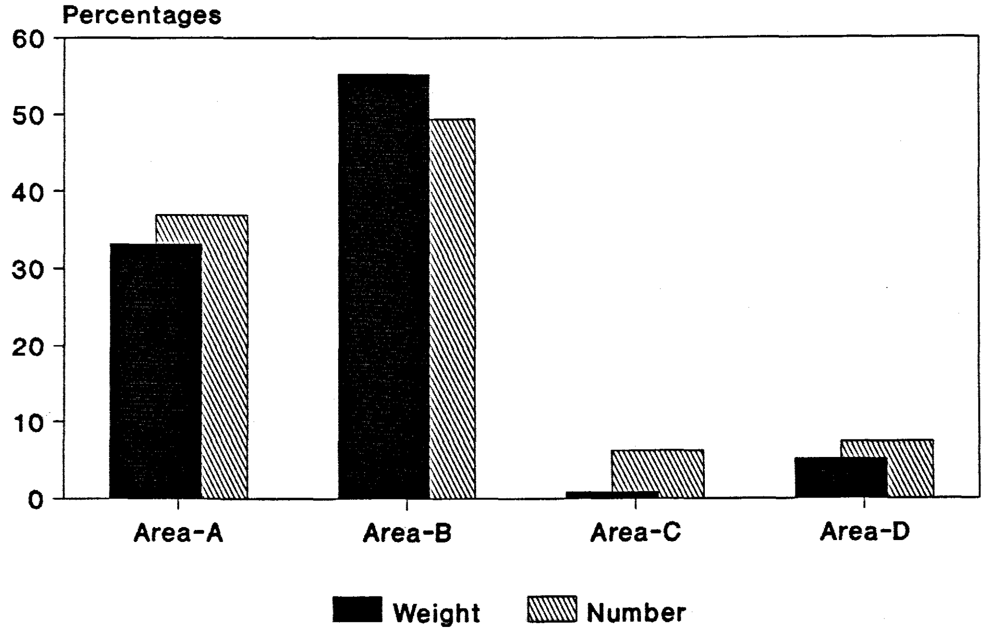


FIGURE 13 Percentages of lithic artifacts for each excavation area at the Norby site. To facilitate comparison, the number and weight of the lithics are provided.

reduction or biface reduction flakes where possible. Material types and the percentages of each within the total lithic assemblage have also been recorded. Because the raw materials utilized at the Norby site are quite variable some discussion regarding lithic resource utilization follows the initial descriptions of the cultural assemblage.

5.2 Chipped Stone

5.2.1 Projectile Points

Six artifacts retrieved from excavations at the Norby site have been classified as projectile points or projectile point fragments. Each of these specimens was recovered from within the bone level or lying just on top of the bone bed and, therefore, are assumed to be part of the cultural assemblage. In other words, the cultural association of the projectile points with the bone bed is not questioned.

Projectile points were made on a variety of raw materials including Knife River flint (3), silicified peat (1) fused shale (1) and chalcedony (1). Only four of the specimens discovered were complete. Two projectile points represent broken dart points; one consists only of the distal half or 'tip' of a projectile point while the second is comprised only of a point mid-section (Figure 14).

Of the four complete dart points, two are typical Gowen Side-notched projectile points characteristic of the Mummy Cave complex. Walker (1980) notes that several of the Gowen site projectile points were either broken or showed evidence of intensive repair and thus may have been intentionally discarded. Since both of the Gowen Side-notched projectile points at the Norby site exhibit extensive reworking and were recovered <u>in situ</u> from the top of the bone bed, it is suggested that these, too, were intentionally discarded rather than lost accidentally.

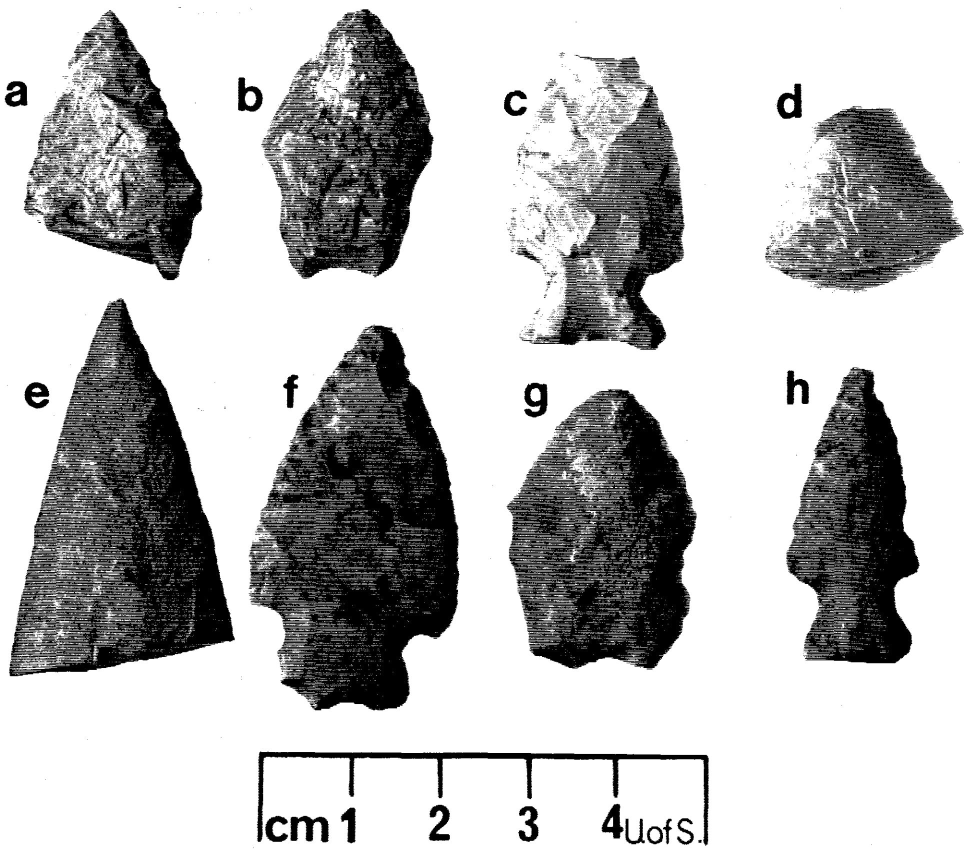
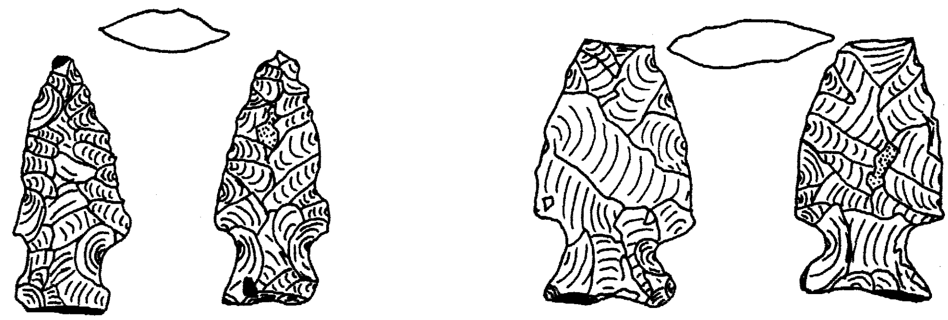


FIGURE 14 Norby site projectile points and preforms. Photo includes Gowen Side-notched projectile points (c,7B-7; h,3B-32), the side-notched projectile point manufacture on a flake (f, 11B-33), a stemmed "Manitoba" point (b,5B-36), preforms (a,25B-75; g,3B-33) and fragments (d,22B-16; e,11A-1).

Overall, the side-notched projectile points are morphologically and metrically similar to those found at the Gowen site. Like the Gowen points, they are symmetrically triangular with the maximum width immediately distal to the notches. The notches, positioned low on a slightly convex lateral margins, are shallow but wide. Both Gowen Side-notched projectile points exhibit basal grinding but one retains a slightly convex base while the second has been ground to such an extent that its base is straight (Figure 15). In cross-section, both specimens are biconvex.

Although the Gowen points are both heavily patinated, it is possible to comment on the flaking patterns of each specimen. Artifact 3B-32 has been flaked extensively on both the dorsal and ventral surfaces. Flakes appear to have been removed systematically; flake scars run parallel to each other on an orientation roughly perpendicular to the medial axis of the dart. In contrast, specimen 7B-7 is more crudely chipped with flake scars placed randomly as an effort was made to thin the tool.

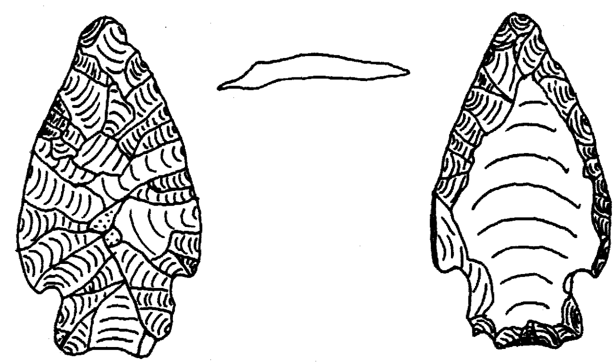
A third side-notched projectile point (11B-33) was manufactured on a Knife River flint flake (Figure 16). It is flaked completely on the dorsal surface but ventrally it shows retouch only along the lateral and basal margins. This specimen is complete with a large, thin body and convex lateral margins. Although its general appearance is similar to the Gowen Side-notched projectile points from the site, the



Dorsal Ventral
(3B-32)

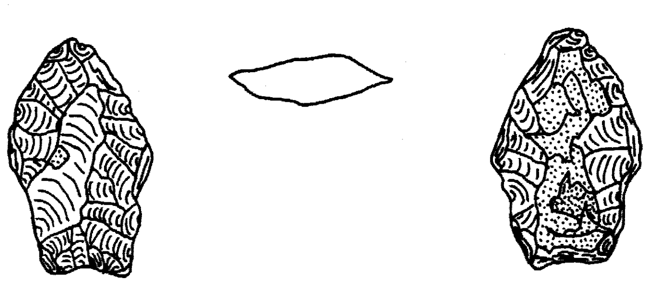
Dorsal Ventral
(7B-7)

FIGURE 15 Gowen projectile points from the Norby site.



Dorsal View Ventral View
(11B-33)

FIGURE 16 Side-notched point from the Norby site.



Dorsal View Ventral View
(5B-36)

FIGURE 17 Norby site "Manitoba" projectile point.

notches are deeper and oriented in a more medial and proximal axis thus giving the shoulders a tanged appearance. This specimen also has a convex base but lacks the basal grinding that tends to be characteristic of typical Gowen points. A partial remnant striking platform is present.

The fourth complete projectile point, manufactured from silicified peat, is very different from the first three described. This specimen is triangular in shape with convex lateral margins which constrict proximally. But unlike the side-notched points, this specimen has a stem (Figure 17). It has been thinned basally with the removal of flakes and lacks basal grinding, a prominent feature of the side-notched variants. The significance of this point and its relationship to other point styles of this time period is important because it appears to be a heavily reworked projectile point known as a "Manitoba" point.

Projectile points of this style were initially recovered in a fairly concentrated area of western Manitoba. The style is described by Pettipas (1972:1) as follows:

> ... basically lanceolate with markedly convex edges. The margins just above the narrow concave base exhibit two or three shallow notches in immediate succession ... Flaking is generally irregular but well-controlled, showing a tendency toward a parallel-oblique pattern. Thickness ... is variable.

Similar specimens have since been described from the Swan Valley in southwestern Manitoba (Gryba 1976, 1981), site "GL" in east-central Alberta (Wormington and Forbis 1965: 92), the

Medicine Lodge Creek site in the Big Horn Mountains of Wyoming (Frison 1976: 166) and the southeastern Canadian Rockies (Driver 1982).

At Medicine Lodge Creek, the levels in which this type of projectile point were located dated to the Paleoindian time period. One specimen (Frison 1978: Figure 2.3c) was aged to 8300 BP and a second (Frison 1978: Figure 2.4c) dated to about 8000 BP. A comparable date of 8500 BP was derived for the site in the Canadian Rockies. The Alberta and Manitoba localities, however, remain undated but an association of stemmed projectile points and Paleoindian points has been suggested (Pettipas 1980: 1).

The discovery of a Manitoba projectile point at the Norby site implies that, at least in Canada, this point style is much later in date than originally anticipated. Rather than a Paleoindian association, the "Manitoba" point seems to be closer in age to Early Side-notched projectile point varieties. The <u>in situ</u> recovery of the stemmed projectile point from the Norby site provides evidence for such an hypothesis. Because the Alberta and Manitoba finds are from undated surface sites, suggesting a direct relationship between the stemmed projectile points and Paleoindian may have been somewhat premature on Pettipas' (1980) part.

The basic metric attributes of both the Norby site and the Gowen site side-notched projectile points are presented in Tables 2 and 3. The sample from the Norby site is too small

TABLE 2 Norby site projectile point metric attributes.

SPECIMEN NO. (CAT.)	MAXIMUM LENGTH (mm)	MAXIMUM WIDTH (mm)	MAXIMUM THICKNESS (mm)	BASAL WIDTH (mm)	LEFT NOTCH (mm)	RIGHT NOTCH (mm)
1 3B-32	33	16	5	12	6	7
2 7B-07	--	20	6	16	9	6
3 11B-33	42	23	6	15	6	5
4 5B-36	31	19	6	15	--	--
5 11A-1	--	--	7	--	--	--
6 22B-16	--	--	6	--	--	--
AVERAGE	34.3	19.5	6	14.5	7	6

TABLE 3 Gowen Site projectile point attributes based on Walker (1980: 69).

SPECIMEN NUMBER	MAXIMUM LENGTH (mm)	MAXIMUM WIDTH (mm)	MAXIMUM THICKNESS (mm)	BASAL WIDTH (mm)	LEFT NOTCH (mm)	RIGHT NOTCH (mm)
1	--	19	7	18	7	7
2	--	23	7	20	8	8
3	--	19	6	--	--	--
4	--	20	5	16	7	7
5	--	--	--	--	--	--
6	35	19	5	14	7	9
7	32	19	6	17	6	7
8	29	18	5	18	5	6
9	--	17	7	17	5	7
10	28	21	6	17	7	8
11	26	17	5	13	6	5
12	--	17	5	16	7	6
13	26	18	5	13	4	6
14	25	17	4	13	5	7
15	23	17	5	14	7	7
16	--	17	6	14	7	7
17	19	16	5	16	8	7
18	18	16	4	16	6	7
AVERAGE	26	18	5	16	6	7

to evaluate any similarities or differences between the two assemblages. However, there does seem to be some correlation in terms of maximum width, maximum thickness, basal width and the sizes of the side-notches in general.

The remaining two projectile points are incomplete (Figure 14: d,e). The first is manufactured from fused shale (11A-1) and consists only of the top portion of a point. It is symmetrically triangular with straight lateral margins. The base is missing from this specimen and therefore it is impossible to classify it as to point type or style. The maximum thickness of this point, however, and the overall method of manufacture, are comparable to the Gowen Side-notched projectile points from the Norby site.

The second incomplete specimen (22B-16), lacking both a tip and base, is also a symmetrically triangular in form. But unlike the rest of the projectile points, this specimen is asymmetrical in cross-section rather than biconvex. In terms of metrics, this specimen, like specimen 11B-33, is comparable only in thickness to the Norby site side-notched projectile points.

5.2.2 Preforms

Two artifacts are considered to be preforms or projectile points (Figure 18). The first, manufactured from Swan River chert, is roughly lanceolate in shape but constricts towards

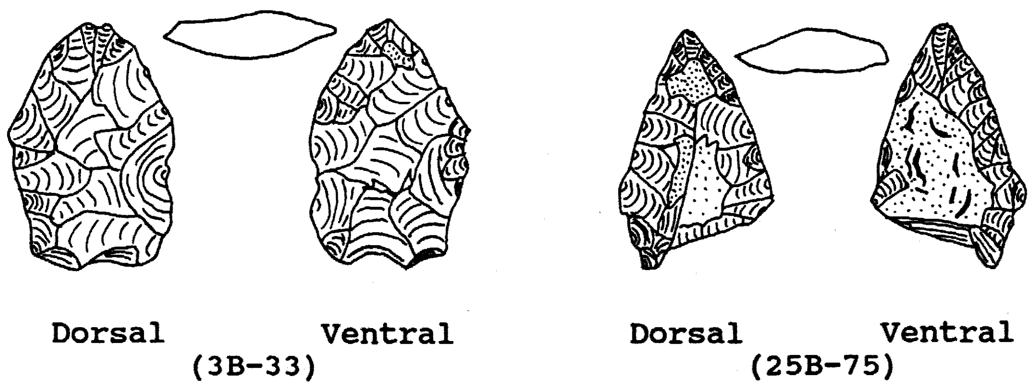


FIGURE 18. Norby site projectile point preforms.

TABLE 4 Metric attributes of Norby site preforms (mm).

CATALOGUE NUMBER	MAXIMUM LENGTH	MAXIMUM WIDTH	MAXIMUM THICKNESS
3B-33	31	21	3
25B-75	--	20	5

the proximal end. There appears to have been some attempt to make a notch along the right lateral margin but the notch itself was never completed. The specimen is crudely flaked on both the dorsal and ventral surface. Several small hinge fractures are visible along the lateral margins but secondary retouch is not evident. It has a slightly concave base with a remnant platform present at the extreme proximal end of the left lateral margin. In cross-section it is biconvex.

The second preform (25B-75) is made from silicified peat. It is triangular in shape with straight lateral margins. Unlike the first preform described, this specimen is asymmetrical in cross-section. The left lateral margin has a shoulder, giving the tool a stemmed appearance. However, because the item is unfinished, the final form and outline of the tool cannot be determined. As with the first preform, this tool is crudely flaked on both surfaces but does not exhibit evidence of secondary retouch. Step-like fractures on the lateral margins may be due to the nature of the raw material. Silicified peat has a tendency to fracture along its irregular parting planes, making the material hard to chip (Johnson 1986:74).

A large hinge fracture on the dorsal surface of this second preform was probably responsible for it being discarded. It appears that an attempt was made to further reduce the thickness of the tool by the removal of a flake from a platform, presumably on the item's basal margin.

However, once the hinge fracture was encountered, the pressure of the flake removal technique resulted in the base of the tool breaking off. Evidence for this is that the tool break ends at the hinge fracture itself.

5.2.3. Bifacial Tools

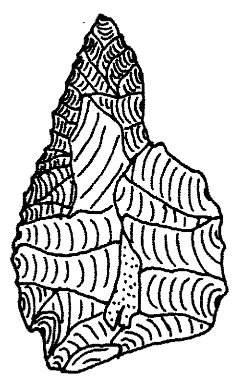
Bifaces are those artifacts that exhibit "intentional retouch covering all or most of the dorsal and ventral faces as well as the lateral edges" (Brumley 1978:74). A total of five such artifacts are represented in the Norby site assemblage, of which only two are complete. Table 5 presents the metric attributes for the complete tools. The broken items, including two tool tips and one body mid-section, are extremely small making it difficult to determine their primary form or function. Therefore, they will not be discussed in any further detail. Raw material types for the bifaces in general include Swan River chert (3), silicified peat (1) and chalcedony (1).

The overall shapes of the complete bifaces are variable but, overall, they tend to be symmetrically triangular with convex lateral margins. One of the specimens is side-notched, while the second is shouldered. They were undoubtedly hafted to some type of handle.

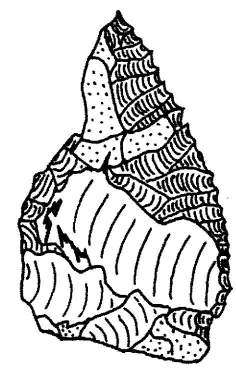
Specimen 10B-50 (Figure 19) is a thin tool with complete flaking on both the dorsal and ventral surfaces. It has a

TABLE 5. Metric attributes of Norby site bifacial tools.

CATALOGUE NUMBER	MAXIMUM LENGTH (mm)	MAXIMUM WIDTH (mm)	MAXIMUM THICKNESS (mm)	BASAL WIDTH (mm)	LEFT NOTCH (mm)	RIGHT NOTCH (mm)
2B-33/ 2B-82	45	27	11	22	--	5
10B-50	40	--	9	15	--	--
Averages	42.5	27	10	18	--	5



Dorsal View



Ventral View

(10B-50)

FIGURE 19 Norby site serrated biface.

Dorsal View

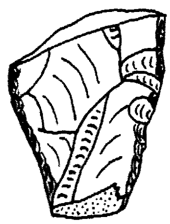
FIGURE 20 Bifacial tool from the Norby site. (Composite tool with catalogue numbers 2B-33 and 2B-82).

large, thin body with pronounced serration along the right lateral margin. The left margin was also probably serrated but, because the tool is broken along much of that edge, a conclusion as to the actual edge form is not possible. Although the majority of the base is also broken, the right basal margin is intact, revealing a small, shallow notch. A similar notch is inferred for the left basal margin.

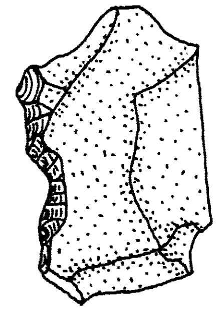
A second complete biface, specimen 2B-33/2B-82, was found in two parts; the tip of the tool was recorded in situ in Unit 2 exposure 1 of Area B while the basal segment was discovered in the unit's fragment bag (Figure 20). It differs from the other specimen in that it lacks the large, thin blade and the side-notched base. It also is somewhat thicker and was thinned, through the removal of several flakes along the basal margin, before it could be satisfactorily hafted.

5.2.4 Unifaces

Ten portions of unifacial tools were recovered at the site. These are tools or tool fragments with "dorsal and/or ventral retouch which does not converge upon a common edge" (Brumley 1978: 82). The majority were simply retouched flakes, fashioned from a variety of raw material types including Swan River chert, Knife River flint, quartzite and Gronlid siltstone. Morphologically, these flakes are extremely variable, following no definite pattern of



Dorsal View
(A-15)



Dorsal View
(15A-59)

FIGURE 21 Some Norby site unifacial tools.

manufacture. Two specimens are of interest however (Figure 21). Artifact A-15, fashioned from a Knife River flint flake, is roughly ovate in shape. This uniface has been broken so its original form is not known. Small flakes were removed along both lateral margins which would have undoubtedly resulted in very sharp cutting edges. The margins are now dulled and show evidence of heavy use-wear. A second artifact, 15A-59, was manufactured from fine-grained Swan River chert. Flakes were removed from its left lateral edge but it appears that intensive use has rounded the cutting surface to a large extent. The shape of the left lateral margin, with a smoothly rounded concavity, seems to infer some type of scraping function, perhaps as a spokeshave.

Two broken unifacial specimens were quite different from the crudely retouched flake tools. Both are proximal tips of what appears to have been triangular tools showing very fine, extensive flaking on the dorsal surfaces. Due to their very small size, however, an inference as to their form or use is impossible to make.

5.3 The Anvil/Hammerstone

One large granite rock, weighing 1.96 kg, was recovered during excavation. Because the Norby site deposits consist exclusively of a fine-grained sandy matrix, it is extremely unlikely that this large stone is naturally occurring or was transported, via a natural process, to the site. A similar situation is noted at the Gowen site where "no stone occurs as a natural constituent of the ... surficial deposits, and it is thus reasonable to assume that all cobbles or pebbles recovered were transported to the site by the prehistoric occupants" (Walker 1980:95). Since the geographical and geological settings at the Gowen site closely parallel that of the Norby site, it is possible to infer that any large rock uncovered at the Norby site was also transported there by the site occupants. The granite cobble recovered, therefore, probably represents an anvil stone or a hammerstone.

Although the type of raw material does not allow one to determine battering and/or abrasion scars, the anvil/hammerstone was found in association with a concentration of bone fragments. It is assumed that the cobble was employed during bone-breaking activities.

5.4 Debitage

The lithic assemblage at the site is dominated by debitage. Of the 176 items recovered, 20 are large core reduction flakes while 110 are small biface reduction flakes. Twenty-one pieces seem to be amorphous, blocky portions of raw material; these have been classified as shatter and will not be discussed here.

By far the most variation, in regard to raw material type, is not seen in the Norby site formed tools but in the debitage (Figure 22). It is interesting to note that "exotic" material, such as Montana agate, were represented only by flakes and microflakes and not by formed tools. The presence of such tools at the Norby site during the time of occupation, however, can be inferred.

5.4.1 Core Reduction Flakes

Relatively common at the site are large, thick, blocky flakes. Most of these have cortex on them and have been collectively classified as decortication flakes. These undoubtedly were produced during the initial stages of core reduction (Hemmings 1987; Wilsmen 1968). Other flakes are large with prominent bulbs, bulbar scars and ripples, probably produced by removal from a nodule with a hard hammer technique (Hemmings 1987: 438). Material types include Swan River chert (65%), fine-grained quartzite (18%), Knife River flint (6%),

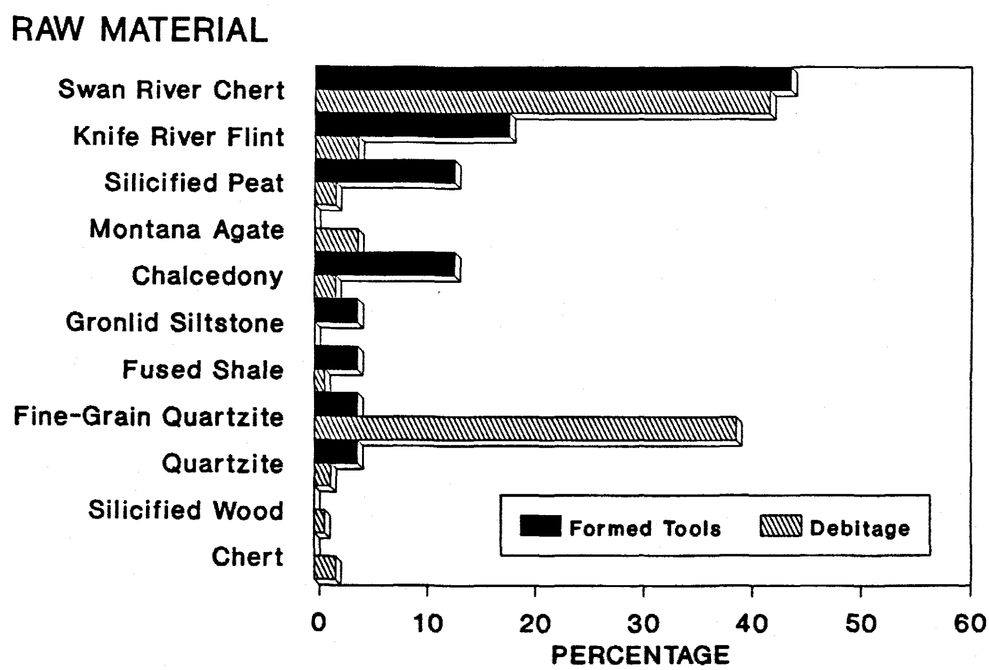


FIGURE 22 Percentages of raw material types represented by debitage and by formed tools at the Norby site.

silicified peat (6%) and chert (6%).

5.4.2 Biface Reduction Flakes

Small flakes at the site can be divided into two categories: those produced by the soft hammer technique and those by a pressure technique. At the Horner site (Frison 1987), flakes which were believed to be produced by a soft hammer technique, are described as follows:

> They are relatively small, thin, expanding and curved in longitudinal cross section. They demonstrate diffuse bulbs of percussion and generally lack prominent ripples or bulbar scars ... The exterior flake surface is marked by scars from previous flake removals, whereas the interior flake surface retains the characteristic, small lenticular platform with lipping at the inner edge (Hemmings 1987: 438).

In contrast biface reduction flakes removed by a pressure technique are described as "markedly thin, parallel sided flakes, long in relation to width, and often demonstrate crushed platforms" (Hemmings 1987: 439). In a similar manner, Crabtree (1972) described pressure flakes as small, thin, long and narrow. They generally are uniform in shape, having "better definition and constant elements of character and therefore, are more diagnostic than those made by percussion" (Crabtree 1972: 17). The microflakes at the Norby site fit nicely into Hemmings' and Crabtree's flake descriptions with the majority being soft hammer percussion flakes (90%) and the remaining group as pressure flakes (10%).

5.5 Lithic Resource Utilization

Several different raw material types were recovered at the site. These included various grades of chert, quartz, quartzite, silicified siltstone pebbles, silicified wood, silicified peat and fused shale.

Of the materials recorded, the most abundant was Swan River chert, making up 60 percent of the total lithic assemblage. This was true not only for formed tools but lithic debitage as well. Such a discovery is not unusual because Swan River chert can be found in large quantities over most areas in east-central Saskatchewan (Johnson 1986). Walker (1980:102) also states that cherts and various grades of quartzite, derived from glacial till, are present in the South Saskatchewan River. Occupants of the Norby site resided on or near the banks of the river and, therefore, undoubtedly had easy access to various types of lithic materials found along the river banks.

Several other local materials, such as silicified peat, silicified wood, Gronlid siltstone and fused shale, were represented in the Norby lithic assemblage. Silicified peat and silicified wood can be found in several local areas of Central Saskatchewan and fused shale has outcrops in both northern and southern areas (Johnson 1986: 79-88). Small nodules of Gronlid siltstone can be found in a glacial drift which extends in a south-western direction from Nipawin, Saskatchewan (Johnson 1986: 88). These are all local areas or areas well within the reach of the nomadic peoples of early Plains prehistory.

Some "exotic" raw materials were also discovered at the Norby site, including Knife River flint and Montana agate. Montana agate is a unique material being opaque in color with characteristic black linear veins running through it. This material, found in western Montana, was represented by only three small biface reduction flakes; but this alone attests to the presence of tools of this material.

The most abundant of the two "exotic" raw materials was Knife River flint; lithic artifacts of this material consisted of small biface reduction flakes, a unifacially retouched flake and three projectile points. Although Gowen I and Gowen II, the other Saskatoon area Mummy Cave sites, had many more projectile points in their lithic assemblages, none of them, interestingly enough, were manufactured from Knife River flint.

Knife River flint is found in northwestern North Dakota, in Dunn and Mercer counties (Frison 1982b: 176), approximately 700 km southwest of Saskatoon. Since this is the closest source of Knife River flint, it is quite probable that the inhabitants of the Norby site either directly obtained this material or received it through a trade network of some kind.

Walker (1980: 102) states that at the Gowen I site "all of the exotic materials were transported to the site probably in the form of finished tools". Although some of the Knife

River flint flakes at the Norby site were undoubtedly the result of sharpening, the presence of large flakes and shatter material suggests that the site occupants transported not only complete tools but nodules of unworked material as well.

5.6 Summary

The lithic assemblage is uncharacteristically small for a bison kill site. Only twenty formed tools were recovered; four of these were complete, heavily reworked projectile points. Two of the complete projectile points, manufactured from Knife River flint, have been classified as Gowen Side-notched, a style which is thought to be diagnostic of the period from 6000 to 5200 BP (Walker 1980). A third projectile point is a stemmed "Manitoba" projectile point as described by Pettipas (1972). The _in situ_ recovery of this stemmed specimen at the Norby site, however, places it at a later date than that originally defined for the style. Initially, the "Manitoba" projectile point was grouped, or thought to be associated, with 8000 year old Paleoindian projectile points (Pettipas 1980). Such a conclusion was based on surface finds only and now, with evidence from the Norby site, appears unlikely.

The presence of biface and core reduction flakes implies that tools were manufactured and subsequently retouched and resharpened at the site. Other tools, along with bison element counts and distribution, suggest that primary butchering was carried out at the site. There is, however, a definite paucity of butchering tools in general. Why this is so is not known, but perhaps excavations missed the most concentrated or principal areas of the site.

CHAPTER SIX

THE NORBY SITE FAUNAL ASSEMBLAGE

6.1 Introduction to Taphonomy and Bone Bed Analysis

Taphonomy, as it was first described by Efremov (1949: 83), refers to the "study of the transition (in all its details) of animal remains from the biosphere to the lithosphere, i.e. the study of a process in the upshot in which all organisms pass out of the different parts of the biosphere, and being fossilized, become part of the lithosphere". It is based on the principle of uniformitarianism which holds that the processes presently affecting faunal assemblages, from the death of the individuals through burial to exposure, are the same as those that acted on bone in the past.

Although taphonomy was defined in the early 1940s, little attention was paid to scientific efforts to formalize the field. Actually, little attention was paid to faunal analyses at all. In fact, at many archaeological sites bone was still being discarded; it was considered secondary to stone tools and potsherds in terms of the cultural information it could provide (Daly 1969: 146). It was only with the work of Theodore E. White that a genuine interest was sparked in the potential contributions of faunal assemblage studies to archaeology.

In the 1950s White published a series of articles dealing with the butchering techniques of American aboriginal peoples (see White 1952, 1953a, 1953b, 1954, 1955). His work centred around observations of bone element distribution frequencies, the calculation of dietary percentages of various food animals and the calculation of the minimum number of individuals (MNI). MNI is that "number of individuals which are necessary to account for all the skeletal elements found in a site" (Grayson 1984:30). White used MNI counts as well as numerous other forms of data in an effort to answer such questions as group cultural affinity, types of occupation, the amount of food being ingested, as well as the species of food animals being taken. Although modified and modernized, the methods originally employed by White remain as the foundation for the methods of faunal analyses and the science of taphonomy that we know today.

During the early 1960s archaeologists began to address many of the questions that were raised by White's butchery studies. It soon became apparent to them, however, that bone beds had been affected by various "disturbance factors"

(Wilson 1983). In other words, the assemblages had been altered in terms of element number and distribution by both cultural and natural taphonomic processes. By utilizing various methods of experimentation and detailed observation scientists found it possible to recognize, to some extent, the processes and agencies responsible for such alteration. Process and agency have been recently defined by Johnson (1985: 158) as follows:

> The agency is the general group to which the phenomenon, causing change in the original state of the bone or bone assemblage, can be classed (eg. biological, geological or hominid). Process is the "how" it became modified ... and the "what" that caused the modification.

Even though certain processes were recognized, very little was done to identify and classify the effects they had had on bone. As a result, the state of taphonomy in the 1960s remained relatively unchanged since that of the 1950s. There was still a considerable need for archaeologists to understand those events that lead to the formation of fossil deposits as well as those post-depositional processes that served to alter bone bed composition and element distribution after deposition.

Once archaeologists began to acknowledge the presence of several voids in their understanding of faunal assemblage formation, the number of analyses involving the identification of the various effects of taphonomic processes increased at an exponential rate. Studies were carried out on bone weathering and its effects on element distribution (e.g. Voorhies 1969; Behrensmeyer 1975, 1978; Behrensmeyer and Dechant Boaz 1980; Issac 1976; Hill 1979; Gilbert and Singer 1982; and Tappen and Peske 1970), on natural versus cultural bone breakage (e.g. Binford 1981; Bonnichsen 1973, 1978, 1979; Morlan 1978, 1980, 1983), on natural versus cultural faunal deposition and the resulting element frequencies (Thomas 1969, 1970; Coe 1980; Frison et al. 1978), and on the identification and placement of various cut marks on bone (e.g. Frison 1970, 1973, 1974; Gilbert 1969; Johnson 1978, 1980; and Wheat 1979).

In addition to experimental studies, several comprehensive papers outlining all the known disturbance processes that could act on archaeological assemblages began to appear in the archaeological literature (e.g. Wood and Johnson 1981; Gifford 1978, 1980, 1981). By the mid-1970s taphonomy seemed to be well on its way to becoming a science with its own set of "laws" (Olson 1980).

With vast amounts of new data on file, archaeologists again turned back to the study of prehistoric butchering practices in an effort to reconsider the hypotheses and preliminary conclusions reached by earlier studies. Today, however, the techniques employed in such studies are somewhat more complicated then those of earlier studies. Minimum number of individual (MNI) counts, as originally defined by White (1952, 1953a, 1953b, 1954 and 1955), are still utilized. But in addition to this, minimum numbers of element (MNE) counts (Binford 1978), minimum animal unit (MAU) counts (Todd 1987), and numbers of identified specimens (NISP) have been utilized. NISP simply refers to "all the bones which have been identified as to a specific element or to a general class of elements" (Brink and Dawe 1989:81); MNE counts the times an element or portion of an element is present in an assemblage but, in contrast to NISP, it does not include fragments of those elements; and MAU is "calculated by dividing MNE by the number of that element in the animal"(Todd 1987: 134). These data are thought to "provide a suitable measure of element content" (Todd 1987: 134) and seem to adequately indicate which bison elements were lost or transported from the site via natural or cultural processes.

Within the last twenty years taphonomy has come to serve another purpose for archaeology. In the late 1960s researchers began to utilize taphonomy as a means to study animal populations. Voorhies (1969: 2) points out that, although concerned with the factors intervening between the living fauna and the fossilization of a fraction of it, taphonomy also deals with the cause of death. In archaeology the cause of death and the animal population represented are directly related, and these facts in turn "provide information on what the humans who were exploiting the animals were doing" (Frison 1976: 288). As a result, animal population dynamics, especially in terms of how it relates to human population dynamics and to population stresses enforced by the environment, have become a focus in archaeological faunal assemblage studies (e.g Frison 1970, 1971, 1973, 1974; Frison and Stanford 1982; Frison and Todd 1987; Reher 1970, 1973, 1974). In such studies, aging and sexing skeletal remains becomes extremely important.

Tooth eruption and wear patterns are the main tool used in determining the age of individual bison specimens. Frison et al. (1976) developed the first standardized method for age determination through tooth wear patterns (See Figure 23). Since that time, various modifications of Frison's original idea have appeared in the literature (Brumley 1990) but, in the end, all serve the same purpose. The technique has been used successfully at a number of bison kill sites (eg. Frison 1968, 1970, 1973, 1974, 1982a; Frison and Reher 1970; Reher 1970, 1973. 1974; Reher and Frison 1980; Todd and Hofman 1987; Todd et.al. 1990), not only for establishing age groups but in determining seasonality of the sites as well. On the basis of this success, the method was also applied to the Norby site upper and lower dentition.

Distinguishing between male and female individuals has also become a focus of archaeological research. Several procedures have been developed to deal with both whole and fragmentary bone elements (Lorrain 1968; Bedord 1974, 1978) Duffield 1973; Speth 1983; Todd 1987; Kline and Cruz-Uribe 1984; Roberts 1982; Morlan 1989); a number of these were employed during Norby site analysis. It is important to know

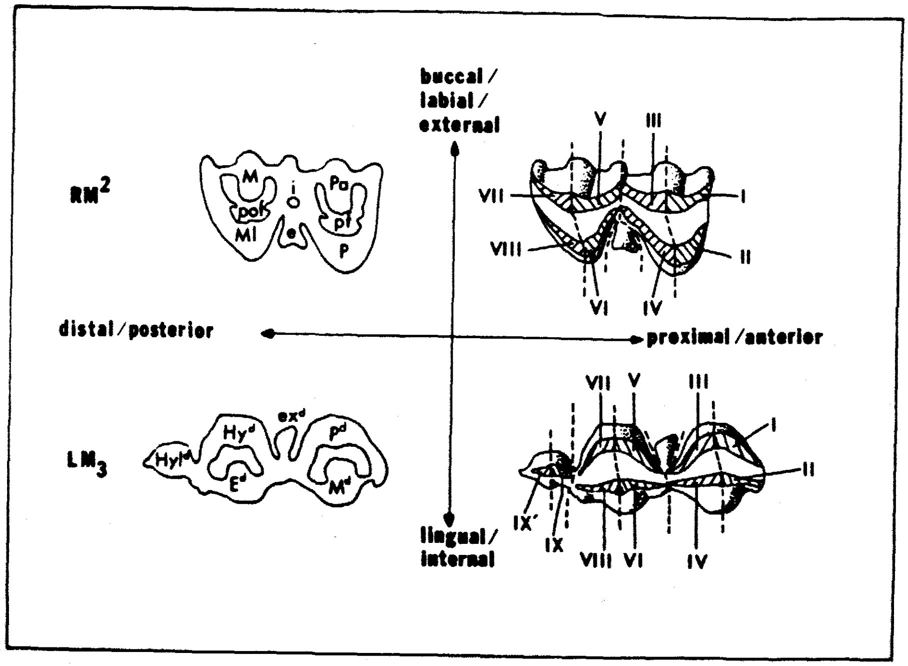


FIGURE 23 Bison dental morphology and wear patterns to aid in aging studies. Upper left: right M2(worn) showing cusps and fossettes. e, endostyle; i, interfossette; M, metacone; Ml, metaconule; P, protocone; Pa, paracone; pf, prefossette; pof, postfossette. Upper right: right M2(lightly worn) showing numbering of wear facets. Lower left: left M3(worn), showing cusps. E, entoconid; ex , exostylid; Hy , hypoconid; Hyl , hypoconulid; M , metaconid; P , protoconid. Lower right: left M3 (lightly worn), showing numbering of wear facets (from Frison et. al. 1976).

the male/female composition of an archaeological sample so that statements can be made regarding general subsistence strategies of prehistoric people. More than once, the behavioral differences between male, male/female and female/calf herds have been noted to affect procurement strategies and subsequently, the butchering processes utilized by groups of prehistoric people (eg. McHugh 1958; Frison 1974, 1978; Frison et al. 1976).

The Norby site faunal remains were analyzed with specific taphonomic goals in mind. What follows is a detailed discussion of the Norby site bone bed in terms of attritional factors, bone bed composition and element distribution. Special attention has been paid to aging and sexing of individual specimens in an effort to determine herd composition and bison population dynamics on the Plains during the Altithermal period.

6.2 Attritional Factors

The condition of the faunal remains was generally poor (Figure 24). Long bones, although complete at the time of burial, fell into pieces as excavation and removal proceeded. Presumably, most bones were exposed for a lengthy period of time before they were buried under a protective matrix. Superficial layers showed the most severe weathering. In many cases, better preserved elements tended to be either compact bones, such as carpals and tarsals, or bones recovered in the second exposure of excavation; the latter were undoubtedly shielded, to some extent, by overlying bone from the effects of pre-burial weathering.

FIGURE 24 General condition of the Norby site bone bed.

It appears then, that the bone was probably exposed to a variety of physical and chemical processes prior to burial. Exposure to sun, rain, wind, river water and so forth were seemingly the most destructive taphonomic agent. A comparable situation is demonstrated by the bone at Head-Smashed-In, Alberta (Brink and Dawe 1989). In contrast to the circumstances at the Alberta site, however, some of the damage to the Norby site fauna can be attributed to floralturbation (Wood and Johnson 1981); much of the bone has been penetrated and damaged by root growth.

To determine the degree of surficial weathering, the Norby site bone was examined employing Behrensmeyer's (1978) six stages of weathering as modified by Todd et al. (1987) for use on the Horner site faunal assemblage (see Table 6). As a whole, the condition of bone was generally ascribable to the fifth or sixth stage of weathering, described as follows:

> Bone is falling apart in situ, with large splinters lying around what remains of the whole, which is fragile and easily broken by moving. Original bone shape may be difficult to determine (Behrensmeyer 1978: 151).

Differential preservation existed in some cases (see Figure 25), but for the majority of the site bone surfaces were so badly weathered that cut-mark analysis was made impossible. When it came to elements recovered in the second exposure of excavation, the most extreme weathering was consistently observed on the surface that was in contact with

TABLE 6 Weathering/deteriorating stages for compact bones (carpals & tarsals) and cortical bone (Todd et al. 1987).

<table>
<tr><th>STAGE</th><th>COMPACT BONE</th><th>CORTICAL BONE</th></tr>
<tr><td>1</td><td>Unweathered, articular surfaces intact with no surface cracking.</td><td>Unweathered</td></tr>
<tr><td>2</td><td>Articular surfaces intact with some longitudinal cracking.</td><td>Limited surface weathering; some longitudinal cracking.</td></tr>
<tr><td>3</td><td>Articular surface exhibits some deterioration; but more than 50% intact.</td><td>Light surface flaking, deeper cracking.</td></tr>
<tr><td>4</td><td>Intact articular surfaces restricted to a few small "islands"; less that 50% intact.</td><td>Patches of fibrous bone with moderate flaking/cracking.</td></tr>
<tr><td>5</td><td>No articular surface area remains intact.</td><td rowspan="2">Deep cracking and extensive surface flaking. Bone is falling apart.</td></tr>
<tr><td>6</td><td>Bone severely deteriorated with large areas of fibrous bone exposed.</td></tr>
</table>

the soil matrix upon burial (Figure 26). It is not clear why such a condition existed. One explanation might involve the proximity of the South Saskatchewan River. Flooding by river waters may have caused the surface on which the bone was discarded to become periodically water-logged. If this were the case, the bone lying on the damp surface would have begun to rot.

Whatever the cause, this type of weathering could be important because it has been noticed at other sites. For example, at the Horner site it was noted that:

> ... a pattern of marked difference in weathering stages on opposite surfaces of individual elements indicates that the subaerial position of the elements was quite stable prior to burial. Had the bones been subjected to repeated movement, the weathering should have been more uniform across the entire cortical surface (Todd et. al. 1987: 68).

Since the Norby site bone exhibited the same weathering pattern as that of the Horner site, it has been assumed that the same conclusions regarding the position of bone elements can be reached. As with the Horner site bones, very little evidence exists for post-depositional movement in the Norby site bone bed.

As mentioned previously, long bones at the Norby site were thought to be whole at the time of deposition. Nowhere at the site was there any evidence of bone breakage for the purpose of marrow extraction, a practice popular in Late Prehistoric archaeological sites like Gull Lake (Kehoe 1973) and the Ruby site (Frison 1971). This suggests that the Norby

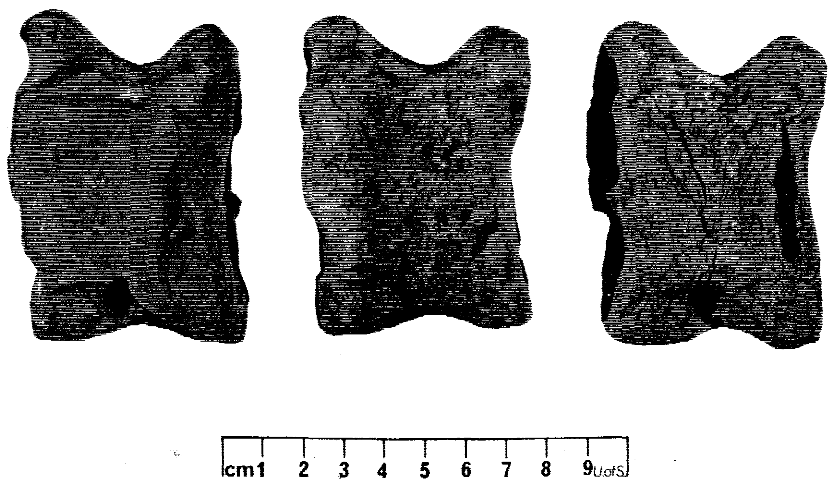


FIGURE 25 Differential preservation of compact bone at the Norby Site.

site is a primary butchering area where only initial processing activities were carried out. Primary butchering is defined as "those initial activities (skinning, dissecting, stripping) that took place immediately upon the death of the animals to prepare them for immediate consumption, transportation and storage" (Zeimens 1982). The only evidence for intensive cultural bone fracture was that of an anvil/hammerstone recovered in association with innumerable skull fragments. It is possible that skulls were being broken open in an effort to extract the brain. However, since complete or nearly complete skulls were not recovered, thereby

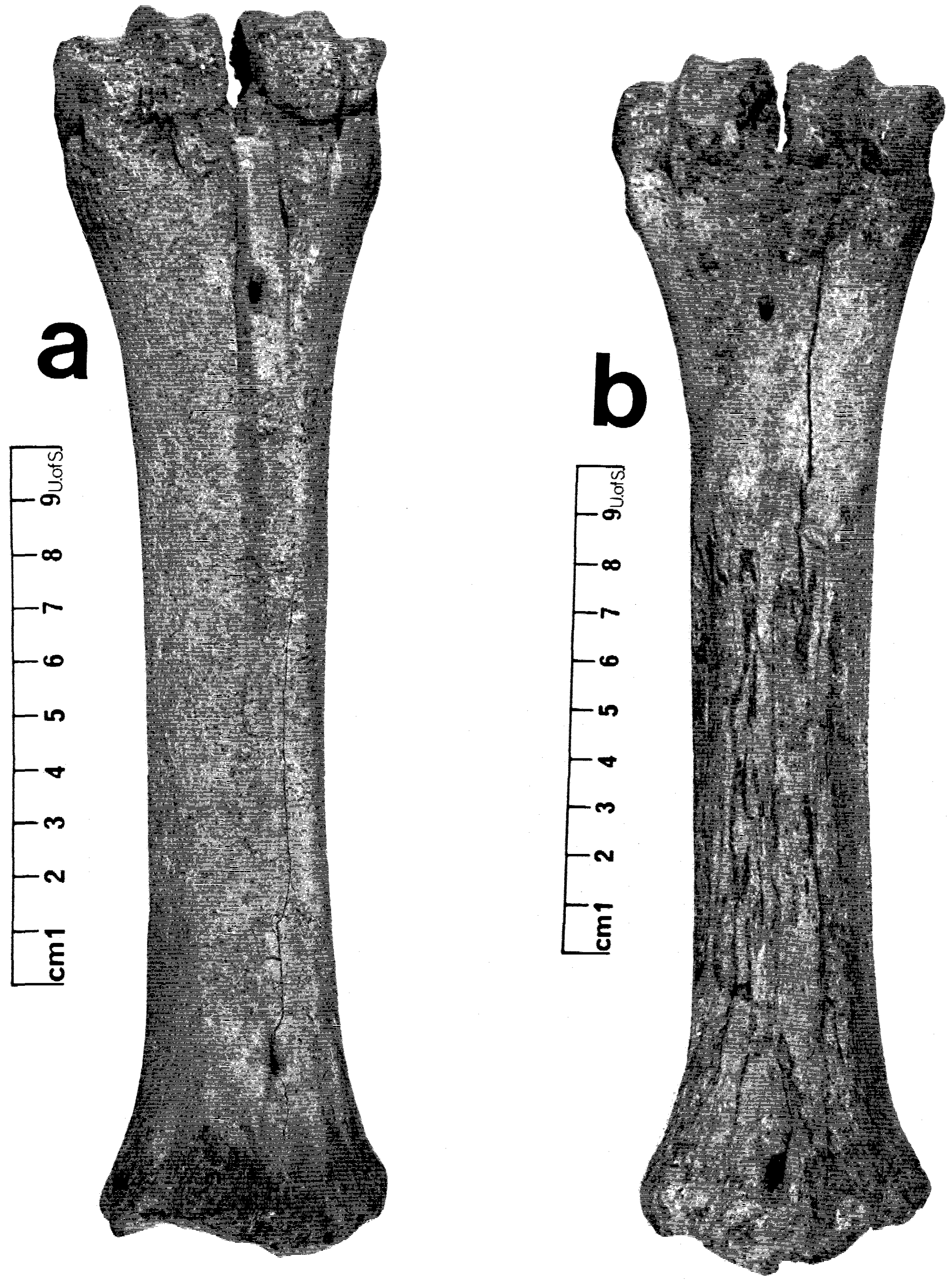


FIGURE 26 Posterior (a) and anterior (b) views of a metatarsal from the Norby site. Note the marked difference in weathering stage on opposite surfaces of this element.

allowing an analysis of fracture patterns, such an hypothesis cannot be substantiated.

Predators undoubtedly had some effect on the faunal assemblage element counts and distribution. In the absence of good preservation, though, determining exactly how much of an effect natural processes have had on the Norby site remains is not possible.

In an effort to provide some answers on the extent of carnivore damage at kill sites, Todd and Rapson (1988) developed a number of quantitative means by which archaeologists could make quick element counts while simultaneously recognizing differential destruction of long bone articular ends. Although it was emphasized that the agent responsible for differential destruction could not <u>always</u> be determined, it was generally felt that the "destruction of articular ends by carnivores, intensive processing by humans,...or post-occupational mechanical or chemical modification can result in systematic, patterned destruction of bone portions" (Binford and Bertram 1977).

After "% Complete" and "% Difference" values were calculated, several patterns were evident (Table 7). Completeness values tended to increase distally with only the radius, due to severe fragmentation, failing to follow the trend. Todd and Rapson (1988) noticed a similar pattern at both the Casper site, where the majority of elements were found complete, and at the Jones-Miller site where bone was

TABLE 7 Percentage difference in representation of proximal versus distal ends of limb bones at the Norby site

	NUMBER COMPLETE (1)	PROXIMAL END (2)	DISTAL END (3)	MAX. NUMBER (4)	% COMP. (5)	% DIFF. (6)
Humerus	0	4	24	25	0.00	71.43
Radius	3	15	13	18	16.67	5.88
Metacarpal	18	5	5	23	78.26	0.00
Femur	0	17	35	35	0.00	34.62
Tibia	4	13	18	22	18.18	12.82
Metatarsal	15	10	11	25	60.00	1.96

$$\%COMP = \frac{\text{Column 1} \times 100}{\text{Column 4}}$$

$$\%DIFF = \frac{\{([\text{Column 1} + \text{Column 2}]-[\text{Column 1} + \text{Column 3}])\times 100\}}{(\text{Column 1} + \text{Column 2}) + (\text{Column 1} + \text{Column 3})}$$

Formulas from Todd and Rapson (1988)

scattered, fragmented and recovered as individual elements. When plotted on a graph, a linear relationship was indicated (Figure 27a), suggesting the "general structure of limb bone fragmentation was remarkably similar" (Todd and Rapson 1988: 309) even though fragmentation levels were extremely different. The same relationship was present when the Norby site completeness values were plotted against those of the Casper site (Figure 27b). At all three sites the humeri were the most fragmented whereas metapodials were most commonly complete.

A second pattern was evident when the "% Difference" values were calculated for the front and hind limbs at the

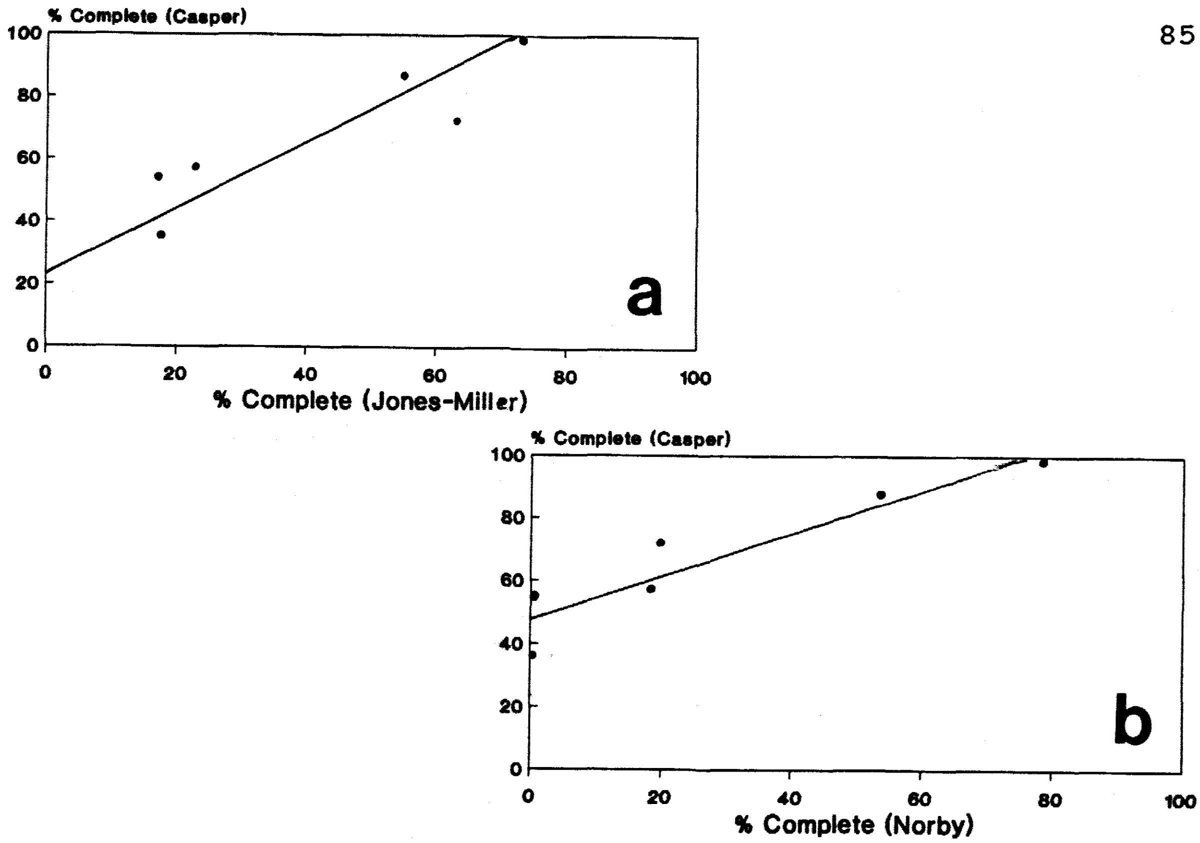


FIGURE 27 Relationships between percentages of complete bones from the Casper and Jones-Miller sites (a), and between the Casper and Norby site (b) (Data from Todd and Rapson 1988).

Norby site. According to Todd and Rapson (1988), the larger the calculated value the more a bone had supposedly been subjected to severe destruction or segment removal. In most cases, except for humeri and femora, the numbers of proximal and distal ends were nearly equal. In other words, the "% Differences" for these elements remained rather small. This suggests that very little preferential selection or destruction by cultural or natural agents has taken place.

A third point was also evidenced by the "% Diff." values at the Norby site. Todd and Rapsen (1988) suggested that there was a tendency for fragmentation index values (Table 7, column 6) to decrease distally for each limb and that this pattern was likely indicative of significant carnivore activity at a site. The Norby site data exhibit this phenomenon, with the highest "% Diff." values exhibited by humeri and femora and the lowest for metapodials. Due to the fragmentary condition of the bone bed however, this was not necessarily a pattern created by carnivore activity but could have also been created by a variety of other natural or cultural processes (Brink and Dawe 1989: 88).

The overall absence of proximal humeri, as at the Norby site, has also been documented at a number of kill sites (eg. Jones-Miller, Olsen-Chubbock, Casper and Lamb Springs); it is a pattern most often attributed to destruction by carnivores. In a study of carnivore activity, and bone destruction in general, Binford (1981: 71-72) had the following to say about element destruction at archaeological sites:

> ...typical carnivore damage to the humerus, and <u>presumably most forms of post-depositional deterioration</u>, usually results in removal of only the thin-walled proximal portions of the shaft and seldom produces destruction of the thicker-walled bone below the deltoid tuberosity (emphasis added).

Because the Norby site bone was probably not subjected to intensive processing, and tooth marks were not found on any of the long bones, the lack of proximal humeri cannot be satisfactorily connected to carnivore activity. However, traces of this activity which may have once been present, were probably obliterated due to the extreme weathering of bone surfaces. Because of this weathering, assessing the degree of damage caused by carnivore activity at the Norby site is a difficult task at best. As a result, the main causes for differential destruction remain unknown.

Figure 28 illustrates the "% Differences" of humeri and tibiae for several kill sites from the Plains region. In their original study, Todd and Rapson (1988) felt that differential destruction of articular ends of long bone was evidenced by such a graph. When the same analysis was conducted at Head-Smashed-In, the results suggested to Brink and Dawe (1989) that such plotting also illustrated changes in the intensity of bison butchering. In other words, primary butchering, which usually occurs at the kill site, is obviously less intensive than secondary butchering conducted at a campsite; the latter is thought to involve intensive processing of bison bone in an effort to extract marrow and bone grease. The Norby site's placement on the graph, near the majority of Paleoindian kill sites, suggests similar butchering situations between them.

To some extent, rodents have altered the Norby site bone. Although on a very small scale, they do modify bone by gnawing (Zeimens 1982: 215). At the Norby site damage was usually restricted to the ends of metapodials, but there was some evidence of chew marks on vertebrae and phalanges as well.

In summary, the faunal assemblage from the Norby site was in a state of poor preservation. Except for some bones

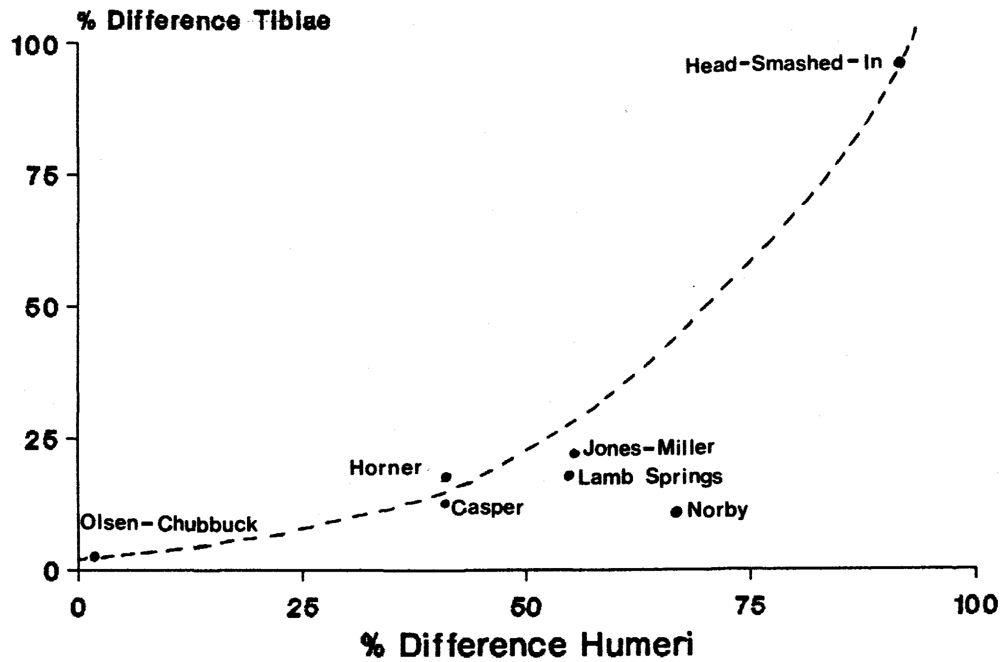


FIGURE 28 Differential preservation of humeri and distal tibiae at the Norby site and other kill sites. (Modified from Todd and Rapson 1988).

recovered in the second exposure of excavation or dense, compact bones like tarsals, carpals and phalanges, the majority of bone elements were extremely weathered and badly fragmented. The degree of surficial degradation made it impossible to distinguish gnaw marks and cut marks. As a result, determining the degree to which taphonomic processes acted on the Norby site bone bed was severely limited.

6.3 Bone Bed Composition

Although the Norby site bone was highly fragmented, it was possible at most times to identify fragments by species, element and side. Only 3.2% of the bone was unidentifiable. The remainder of the faunal assemblage was identified as bison except for two left rabbit metatarsals and two complete canid mandibles. Two animals were represented by the rabbit elements and one animal by the canid jaw. Some small rodent bones were also recovered, but these were probably intrusive and will not be included in the cultural assemblage discussion.

Bison bone was analyzed in detail. The following discussion includes a calculation of the degree of fragmentation, various element counts (MNI, NISP, MNE, MNE%, MAU and MAU%) and bone distribution in general.

6.3.1 Non-Bison Faunal Remains

The only non-bison remains recovered during excavation of the Norby site, other than two left rabbit (<u>Lepus</u> <u>sp</u>.) metatarsals, consisted of a complete lower dentition from a large canid. Although the mandibles were found together at a depth of 90 cm below surface, no other canid remains were uncovered. The lack of post-cranial remains, along with the fact that the mandible was found 8 cm above the rest of the bone bed, leads one to suspect that the mandibles were redeposited on top of the bone bed.

Even though it is not stratigraphically part of the Norby site cultural assemblage, the old appearance of the bone, as well as the age of the animal itself warrants some discussion.

The specimens are in remarkably good condition considering the archaeological age of the deposits in which they were located. The mandibles are complete except that both are missing the third molar, and the second molar is absent from the left mandible. These teeth were lost prior to excavation.

Obviously, the mandibles are from an extremely old animal (see Figure 29). Not only were the teeth badly worn, but a canine and the first two premolors (P1 and P2) from the right side of the jaw had been lost. The apertures were long healed and some of the alveoli had been reabsorbed as a direct result of the tooth loss. The loss of its primary teeth would have undoubtedly affected the hunting habits of this animal.

In the past, archaeologists have attempted to distinguish between species of prehistoric canids by overwhelmingly utilizing only features and metric attributes of the skull (eg. Clutton-Brock 1969; Lawrence and Bossert 1967; Olsen 1985; Walker and Frison 1982). Beebe (1980: 163-165), however, has defined several mandibular features that distinguish wild canid species (<u>Canis</u> <u>sp</u>.) from domestic animals (<u>Canis</u> <u>familiaris</u>). The first feature, a turned-back apex and overhang of the coronoid process of the ascending

FIGURE 29 Redeposited wolf mandibles uncovered above the Norby site bone bed. Note the loss of anterior teeth in the right jaw and the extreme tooth wear in general.

ramus, characterize both the domestic dog and Chinese wolf (_Canis lupus chanco_ (Olsen and Olsen 1977) but are rare in wild canids. In addition, the congenital absence of the first premolar and a diagonal placement of the second premolar are rare in wild canids but common in domestic species. Morlan (1978) also notes several features of the mandible that distinguish dogs (_Canis familiaris_) and wolves (_Canis lupus_) from coyotes (_Canis latrans_). These include the size, placement and orientation of different teeth.

When the above features and the overall size of the mandibles (see Appendix I for measurements) are considered, it becomes apparent that the Norby mandibles are those of a wild canid, probably a wolf. The location of the mandibles, along with the lack of post-cranial remains leads me to suggest that this animal died at some other locality and then only the jaw was transported, via a natural or cultural agent, and redeposited on top of the bone bed.

6.3.2 Element Counts

A total of 2970 complete or fragmentary bison bones were recovered from the Norby site excavations. Of these, 437 (11,511.6 gm) were unidentifiable bone, vertebral parts and ribs. There was also 82,566.5 grams of very small, fragmented pieces of unidentifiable bone (see Table 8). On average there were 1651 grams or 4570 individual bone fragments per meter square.

MNI values, which reflect the minimum number of individuals necessary to account for all elements present at a site, have been tabulated for the Norby site excavation areas. An MNI of 26 animals was calculated using the fused central and fourth tarsal, an element that was well preserved at the site. MNI's were also reported for a number of other elements (Table 9), with the exception of vertebrae, which were rarely found as whole elements. In general, MNI values were high, falling into a range of 16 to 26. Only the 1st tarsal was not as well represented, with an MNI of 10. Due to the size of the 1st tarsal, however, such an under-representation is not considered unusual.

When utilized collectively, MNI numbers attest to the presence of about 78% of the possible number of skeletal remains expected to be present at the site for an MNI of 26 animals. This tends to be a relatively high value when compared to that from other kill sites. For example, at the Agate Basin site there was only ten to thirty-five percent of the expected number of appendicular elements represented at the kill (Zeimens 1982: 227). In the Garnsey site study, it was concluded that those elements with highest utility values were not as well represented as those of low utility (Speth 1983: 85). In other words, the most important parts of the bison were removed from the site, presumably to be processed

TABLE 8 Weights of bison element, portions of elements and fragments recovered at the Norby site. Weights are all in grams.

ELEMENT	WEIGHT	PERCENT
Atlas	5735.3	2.0
Axis	3277.5	1.0
Cervical Vertebrae	9951.3	4.0
Thoracic Vertebrae	17300.4	6.0
Lumbar Vertebrae	2583.4	1.0
Caudal Vertebrae	518.7	---
Vertebrae/Ribs	2235.0	1.0
Unidentified Vertebrae	13276.8	5.0
Scapula	10517.1	4.0
Humerus	23253.4	9.0
Radius	17074.7	6.0
Ulna	5549.7	2.0
Innominate	7717.3	3.0
Femur	21074.9	8.0
Tibia	18576.7	8.0
Metacarpal	9904.4	4.0
Metatarsal	12475.7	5.0
Metapodial	1870.3	0.5
Bone Fragments	82566.5	30.0
Burned Bone Fragments	2727.0	1.0
Tooth Fragments	1972.5	0.5

TABLE 9 Minimum number frequency of <u>Bison</u> <u>bison</u> <u>sp</u>.

	COMP. LEFT	COMP. RIGHT	DIST. LEFT	DIST. RIGHT	PROX. LEFT	PROX. RIGHT	MNI
Petrous	25	25					25
**Altas	27						23
Axis	16						16
Scapula	0	0			25	21	25
Humerus	0	1	15	18	2	2	19
Radius	2	1	22	18	15	20	24
Ulna	0	1			17	20	21
Radial	24	21					24
Ulnar	14	23					23
Internal	16	17					17
Unciform	11	22					22
Accessory	17	14					17
Fused 2/3 Carpal	16	24					24
Metacarpal	8	10	9	14	9	15	25
Femur	0	0	13	23	8	9	23
Patella	15	15					15
Tibia	3	1	17	16	10	10	20
Lateral Malleolus	20	13					20
Astragalus	17	23					23
1st Tarsal	7	10					10
Fused 2/3 Tarsal	16	17					17
Fused Central & Fourth	25	26					26
Metatarsal	16	16	6	4	3	3	22

** total number of C1's includes fragments further at a nearby campsite. Such is not the case at the Norby site. When MNI's are considered, it appears that very little of the Norby site bone was removed from the site by cultural processes or otherwise.

At first glance, MNE, MNE% (MNE/NISP) and MAU% (MAU/MNI) ratios appear to compliment those from the Garnsey and Agate Basin kill sites (see Table 10) in that high utility items seem to be present in small amounts and low utility items in large numbers. This however is a direct contradiction to the preliminary conclusions reached by the MNI numbers. A solution to these opposing statements may be found through the use of Binford's (1978) "Modified General Utility Index" (MGUI).

In the past ten years it has become relatively common for archaeologists analyzing kill sites to utilize MGUI, which assigns economic importance to skeletal parts, as a means for commenting on the butchering and transporting habits of prehistoric people. In the majority of cases, when MGUI are plotted against the MAU% from various sites, a reverse utility curve usually results. These curves have subsequently been interpreted as follows: primary butchering of the animals was undertaken at the kill site and then the higher utility skeletal parts, those with larger amounts of meat, marrow and grease, were transported elsewhere.

Although plausible, the above explanation has been questioned. An alternative hypothesis has been put forward by Lyman (1984, 1985), and further substantiated by Grayson

TABLE 10 Element counts at the Norby site.

	NISP	MNE	MNE%	MAU	RATIO MAU
Skull - Petrous	50	50	100	25.0	96
Atlas	26	7	27	7.0	27
Axis	16	7	44	7.0	27
Cervical	60	18	30	1.0	4
Thoracic	144	19	13	3.6	14
Lumbar	24	4	17	1.4	5
Sacrum	14	3	21	3.0	12
Caudal	65	41	63	4.1	16
Scapula	29	0	10	0.0	0
Proximal Humerus	21	4	29	3.0	12
Distal Humerus	25	18	72	9.0	35
Proximal Radius	38	12	32	6.0	23
Distal Radius	34	15	44	7.5	29
Ulna	39	1	3	1.0	4
Radial Carpal	45	45	100	22.5	87
Ulnar Carpal	37	37	100	18.5	71
Internal Carpal	33	33	100	16.5	66
Unciform Carpal	33	33	100	16.5	66
Accessory Carpal	31	31	100	15.5	62
Fused 2/3 Carpal	40	40	100	20.0	77
Prox. Metacarpal	36	25	69	12.5	48
Dist. Metacarpal	36	23	64	11.5	44
Proximal Femur	42	4	10	2.0	8
Distal Femur	35	9	26	4.5	17
Patella	30	27	90	13.5	52
Proximal Tibia	43	10	23	5.0	19
Distal Tibia	32	15	47	7.5	29
Lateral Malleolus	33	30	91	15.0	58
Talus	40	38	95	19.0	73
Calcaneus	48	41	85	20.5	79
Fused 2/3 Tarsal	33	33	100	16.5	66
Fused Cental & 4th	51	51	100	25.5	100
Prox. Metatarsal	35	15	43	7.5	29
Dist. Metatarsal	38	30	79	15.0	58
1st Phalanx	175	170	97	21.9	82
2nd Phalanx	184	175	95	21.9	84
3rd Phalanx	160	150	94	18.8	72
Superior Sesamoid	107	107	100	13.4	51
Inferior Sesamoid	78	78	100	9.8	38

MAU values based on MNI of 26 animals

(1989), to explain the reverse utility curve. Both feel that the reverse curve is not a reflection of the transportation of select parts away from a kill site, but rather represents density-mediated bone destruction (Grayson 1989: 645). In other words, compact bone, such as phalanges, carpals and tarsals, have a better chance of being preserved at a site in comparison to thin-walled bone like scapulae, pelvi and proximal humeri. The bone fragmentation at the Norby site seems to provide support for Grayson's hypothesis. When the Norby site MAU% values are plotted against MGUI figures a distinct reverse utility curve results (Figure 30). This has been interpreted as representing fragmentation, not transportation.

MNE, MAU and MAU% ratios are considered to provide additional evidence for differential destruction of skeletal elements at the Norby site. Figure 31 presents MAU% values for appendicular skeletal elements recovered at the Norby site. According to this chart, there appears to be a distinct absence of long bones, which are high utility items, at the site. These figures, however, are misleading. Due to severe fragmentation of the bone bed, long bones are not found as whole elements and, as a result, MNE numbers are relatively low. When these are used to calculate MAU% (MNE/MAU), the resultant values are also low.

The extreme levels of fragmentation are also apparent when MNE% are considered (Figure 32). MNE% (MNE/NISP)

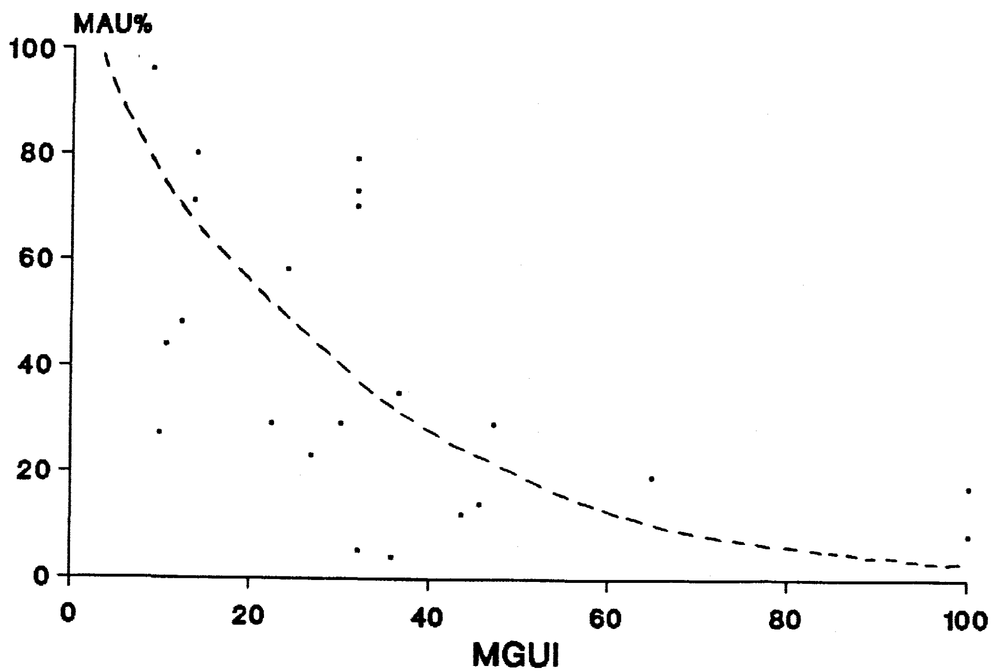


FIGURE 30 Comparison of Binford's MGUI with the MAU% for limb bones from the Norby site.

records the percentage of complete elements present at the site. In general, MNE% values fall well below 50 percent for the various long bone elements, or portions thereof, at the site. The only elements that are found consistently as whole elements are small compact bones like carpals, tarsals and phalanges. Although fragmented, whole long bone elements were present at the site, and in relatively large numbers, before they were removed during excavation. MNI counts attest to

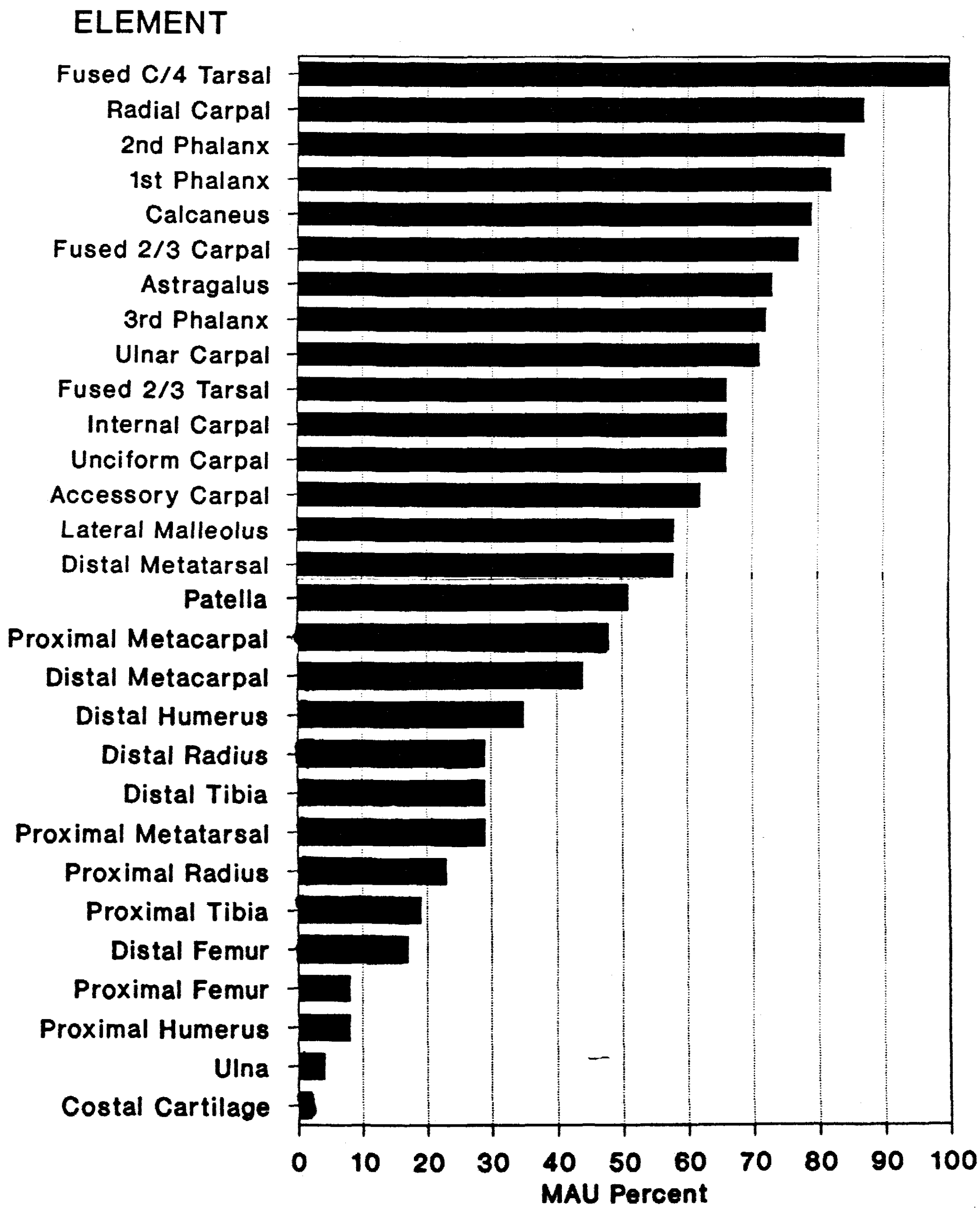


FIGURE 31 MAU% for the Norby site appendicular skeletal elements. Note the low values for long bones in comparison to those for compact bones like carpals, tarsals and phalanges.

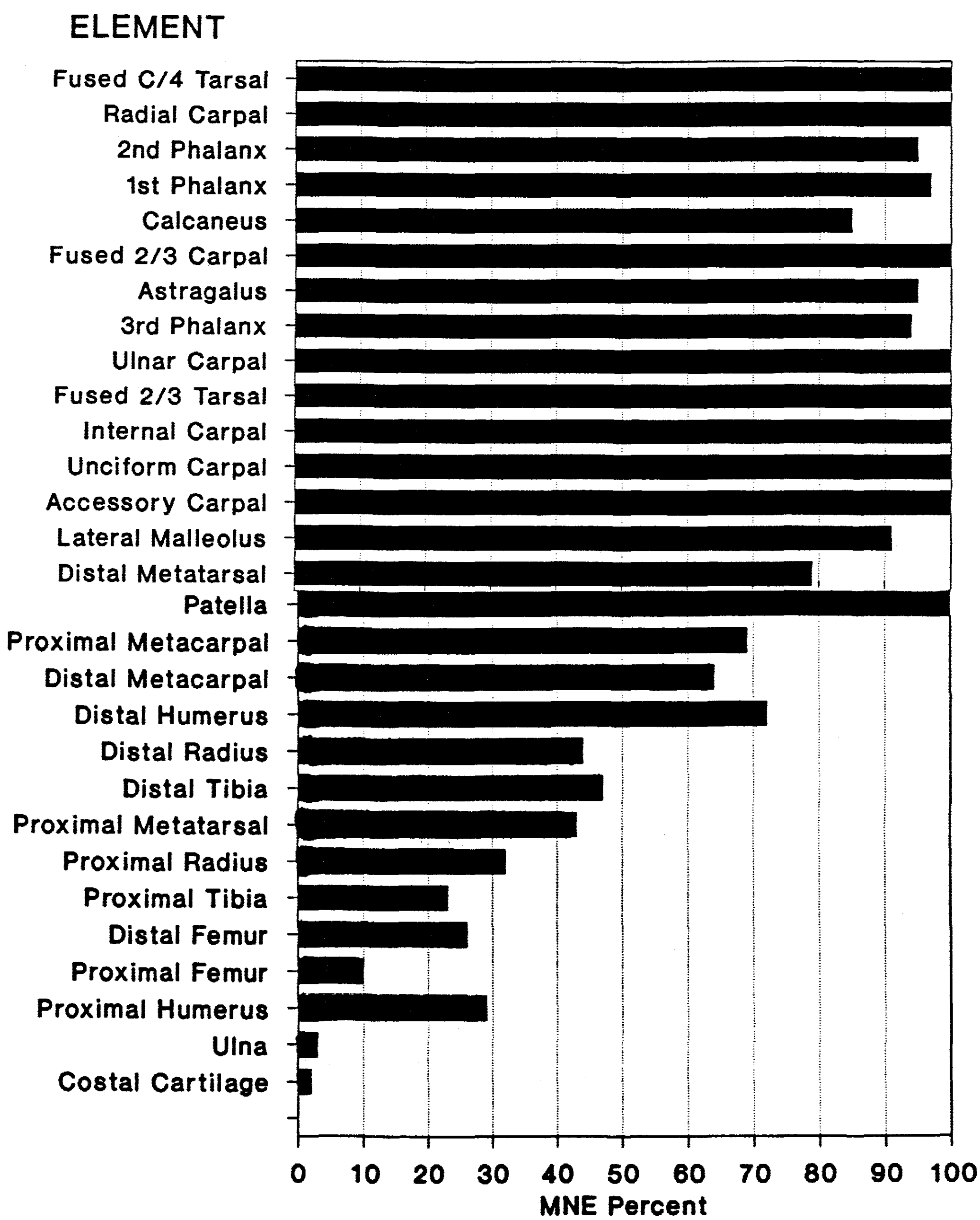


FIGURE 32 MNE% for the Norby site. Note the absence of complete limb bones or portions thereof.

this, and therefore, appear to be far more accurate as a means of determining element frequencies at the Norby site.

It appears, then, that very little bison bone from the Norby site was selectively removed by cultural or natural agents. Low MAU% values can be attributed to differential destruction and fragmentation of certain low-density elements at the kill site.

6.3.3 Element Distribution

The bone bed was variable in thickness throughout much of the excavated areas, with large concentrations of bone in certain sectors. Figure 33 presents the differential distribution of bone at the site utilizing NISP numbers per square metre. What immediately becomes apparent from such an analysis is that the areas with the highest densities of bone are in the southwest corner of Area A and the northwest corner of Area B. In other words, these bone concentrations seem to extend beneath the McDonald and Norby garages. It is quite possible that the main part of the site lies beneath these structures; such a circumstance precluded excavations being carried out in that area.

In the end, excavations carried out at the Norby site may have only recovered a comparatively small sample of the population that was actually present at the kill. Although

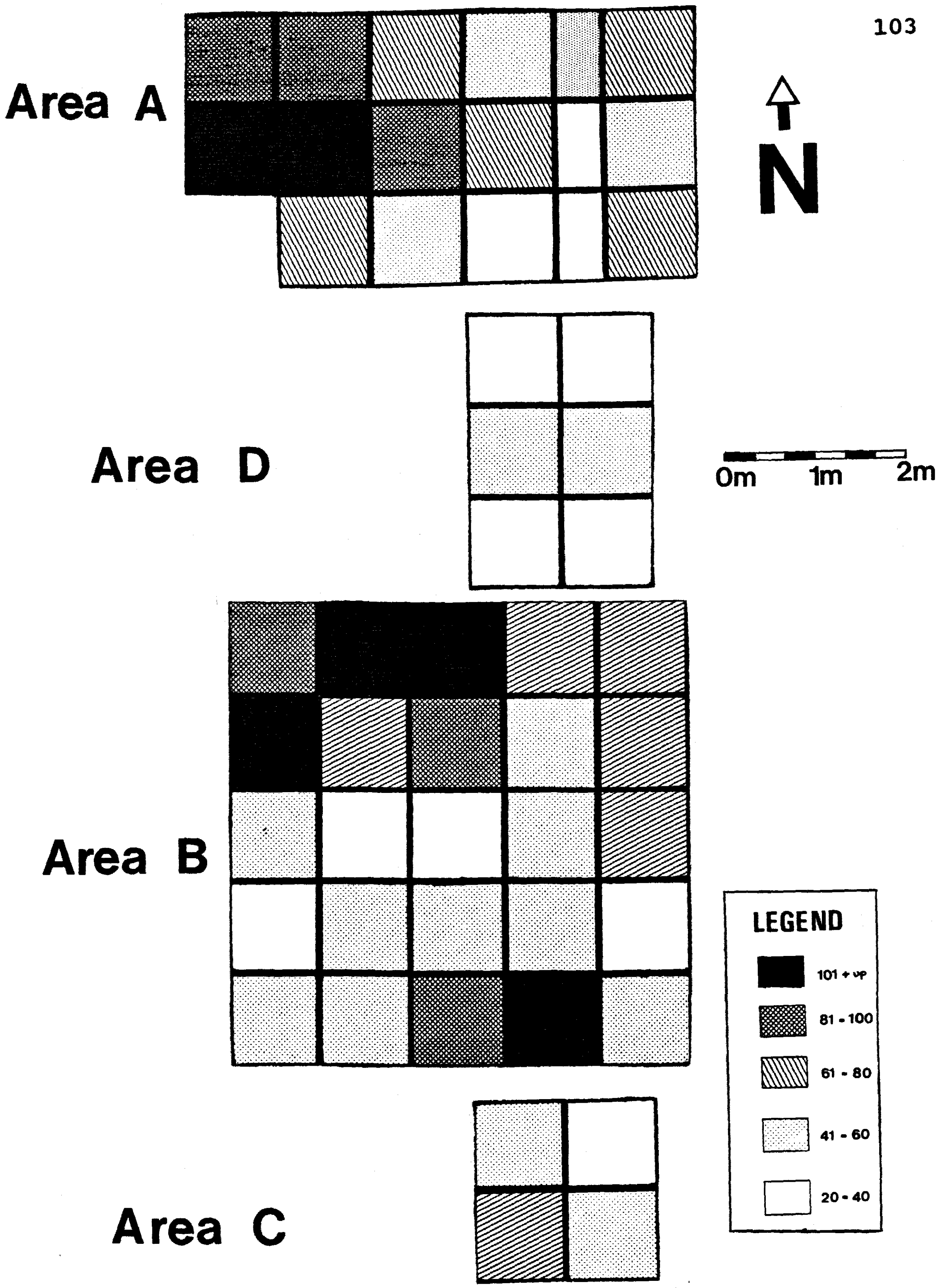


FIGURE 33 Bone bed density at the Norby site. NISP numbers were utilized.

fifty square metres of excavation were complete, the site is estimated to be at least 70 to 100 metres wide while the length remains unknown. In addition, the nucleus of the site is probably beneath the garages and the alley way to the west, areas that cannot be excavated.

Area B, the largest unit of excavation at the Norby site, possesses two areas of bone concentration. In addition to the concentration in the northwest corner, a second one is present along the south wall of the excavation. Between the two there appears to be a "pathway", in an east-west direction through the middle of the excavation area, where there is a distinct paucity of faunal materials (Figure 34). A similar phenomenon is present in Area A, but not to the same extent, in that areas where the bone bed dwindles are restricted to small, circular sectors (Figure 35). Although limited, these may have been areas where people were standing as bison butchering was carried out.

In addition to the large concentrations of bone, there were small concentrations in all areas of the site. The content of these small piles was extremely variable, but in all cases, none of the elements were in articulation; all were individual, isolated specimens. It seems that as bison were butchered, elements were either stacked or randomly thrown into piles.

As previously mentioned, cut marks as well as all other evidence of butchering, was obliterated from the assemblage

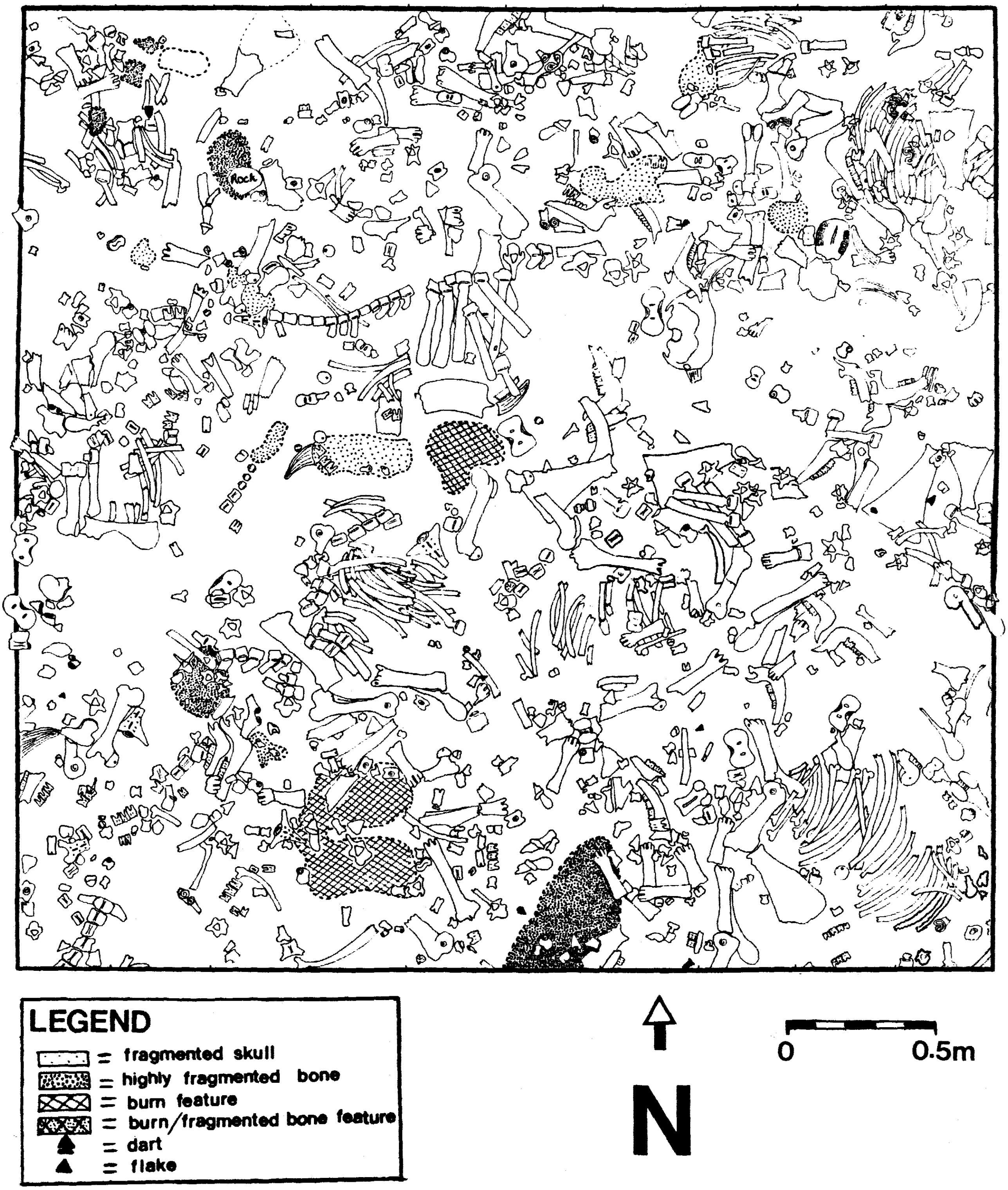


FIGURE 34 Map of exposure 1 bone distribution in Area B of the Norby site.

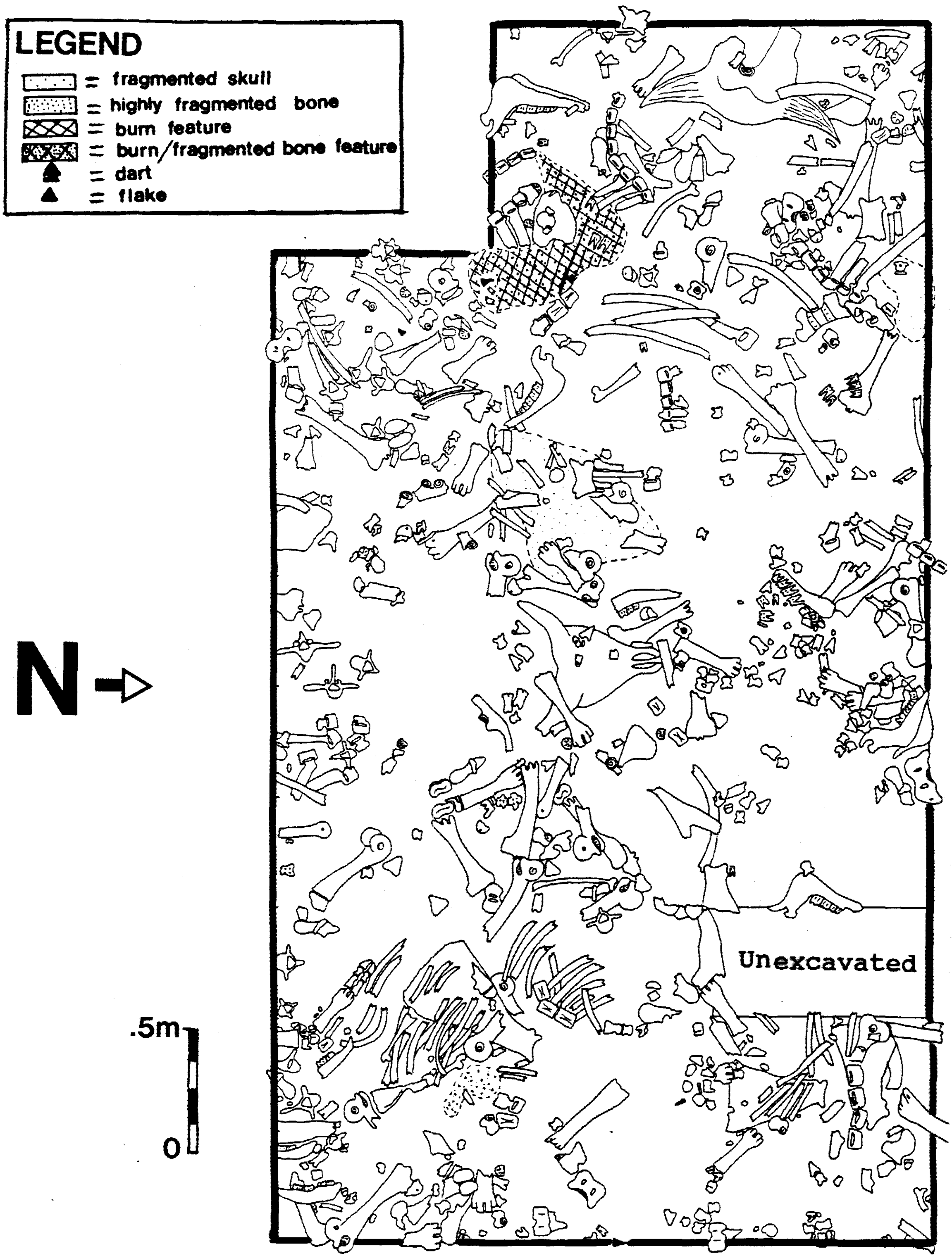


FIGURE 35 Map of bone distribution in Exposure 1 of Area A at the Norby site.

by post-depositional processes. However, it was possible to distinguish several articulated appendicular and axial skeletal units (Figures 36 and 37); ten were of the front leg and five the hind leg, twelve were axial skeletal units, and five, rib piles. Some rib units, lacking rib heads, were found in sequential position suggesting that these units were broken off and the meat subsequently removed. This pattern of butchering is evident at other kill sites such as the Glenrock (Frison 1970) and Carter/Kerr-McGee (Frison 1984) sites. Further evidence for this type of butchering was the fact that ribs and rib heads were sometimes found still articulated with the axial skeleton.

It is interesting to note that seven of the front limb units involve an articulation of the scapula and humerus, three of these include the ulna and radius as well. Apparently the front limbs were being removed from the bison carcasses in the initial stages of butchering. But, because the MNI's for front limb elements approach that for the site in general (scapula = 25; humerus = 19; ulna = 21; radius = 24), it appears that they were not transported elsewhere for further processing.

A large number of crania had been left behind at the Norby site (Figure 37). These elements, along with the teeth in many cases, were badly deteriorated. As a result, analysis was severely limited. In the majority of cases, crania were found isolated from the axial skeleton but were located along

FIGURE 36 Articulated units in Area B of the Norby site.

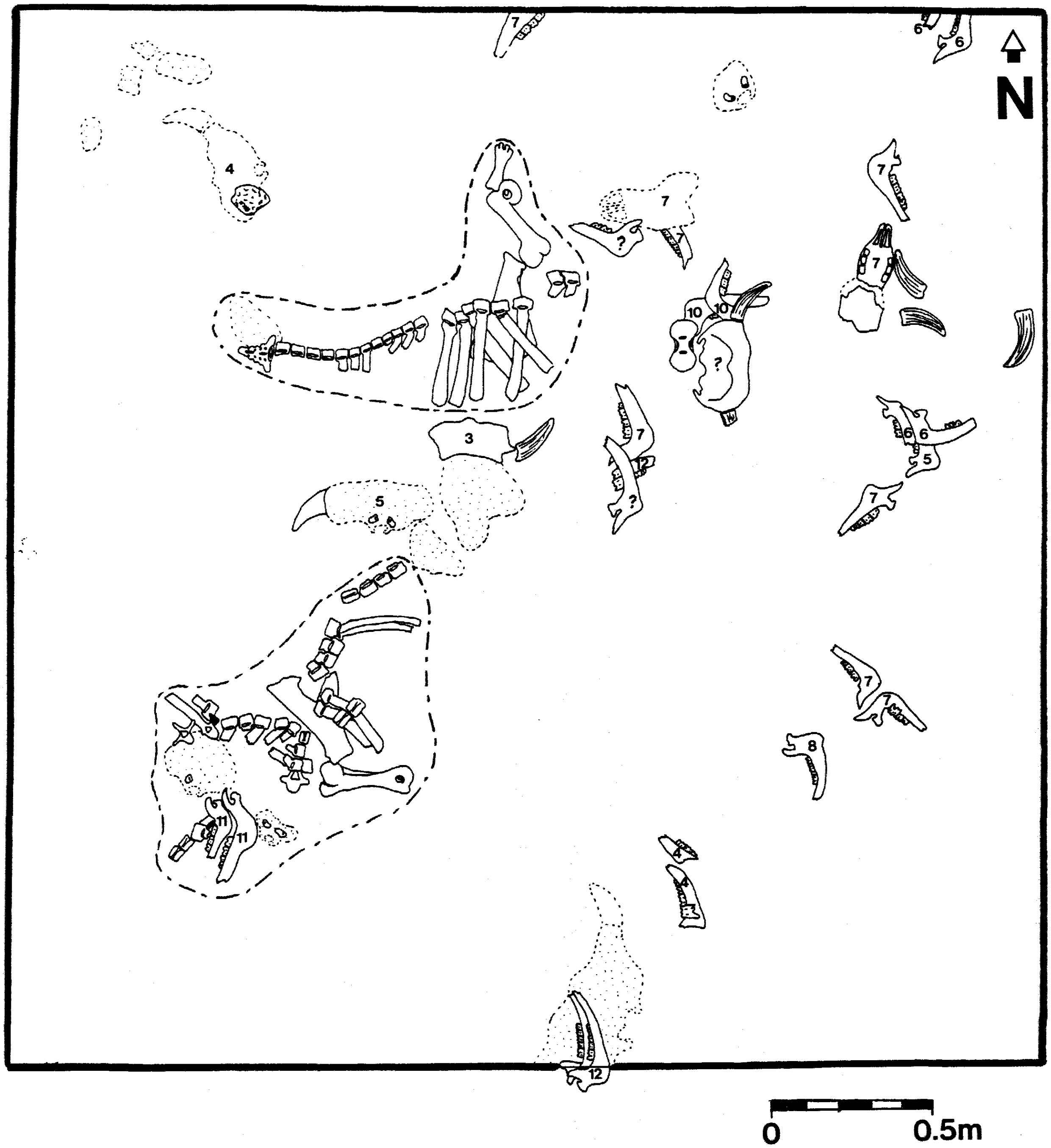


FIGURE 37 Map of partially articulated skeletons in Area B of the Norby site. Cranium and mandible ages have been labelled where possible.

with, or associated with, mandibles. In three specific incidences, maxillary teeth from a cranium and teeth from the associated mandible(s) were independently aged to the same age groups. This suggests that the associated elements were from a single individual. In addition, since mandibles and maxillae were aged independently, it tends to provide support for the validity of the aging methods utilized in this study.

Several mandibles were also recovered but again, these were poorly preserved. Mandibles were commonly found as pairs and, in general, these tended to represent single individuals. At other times, small piles of mandibles were retrieved. These conglomerations sometimes represented as many as three or four individuals. It appears, then, that as animals were butchered, some mandibles were being detached from the skulls and discarded into piles.

Although most of the mandibles appeared to be complete before they were removed from the ground, there were specimens that were broken. Broken mandibles were usually missing the coracoid process and/or the entire ascending ramus. This suggests that they were probably being separated from the cranium in a manner similar to that described by Frison (1970: 22) for the Glenrock site. This process is a follows:

> ... the most common method was to place the skull face down and with a reasonably heavy, blunt-pointed hammerstone, direct sharp blows downward and slightly inward to the temporal condyles and break them off at the point of articulation with the mandibles. This destroys the zygomatic arch and the force of the blow often carried through with sufficient force to break off the coronoid

> process of the mandible. After this, the mandibles were quite free and removed. (Frison 1970: 22).

In one instance a partially complete bison axial skeleton, from the sacrum to the cervical vertebrae and including an articulated scapula and humerus, was found (Figure 37). One of two crania, both of which were located fairly close to this spinal column, could possibly belong with this individual. Figure 37 also shows a second possible example of an axial skeleton associated with a scapula, humerus and cranium. However, in the second case, the articulation is not as clear. Rather, elements are scattered but still associated to a point where they could be considered to represent one animal. Uncovering complete or nearly compete animal skeletons is a relatively common occurrence at kill sites (for examples, see Wheat 1972; Frison 1974, 1982a). The presence of such finds at the Norby site supports the hypothesis that this is a kill and primary butchering area.

Direct evidence for intensive processing is extremely rare at the Norby site. Pulverizing bone in order to extract marrow and grease does not seem to be have been a priority with the occupants of the site. Some crania, however, were found to be more heavily fragmented then others. This may reflect the processes involving the extraction and preparation of the brain for consumption. In the southwest corner of Area A a hearth feature (Figure 38) was encountered and associated with it were four extremely fragmented crania. It is possible

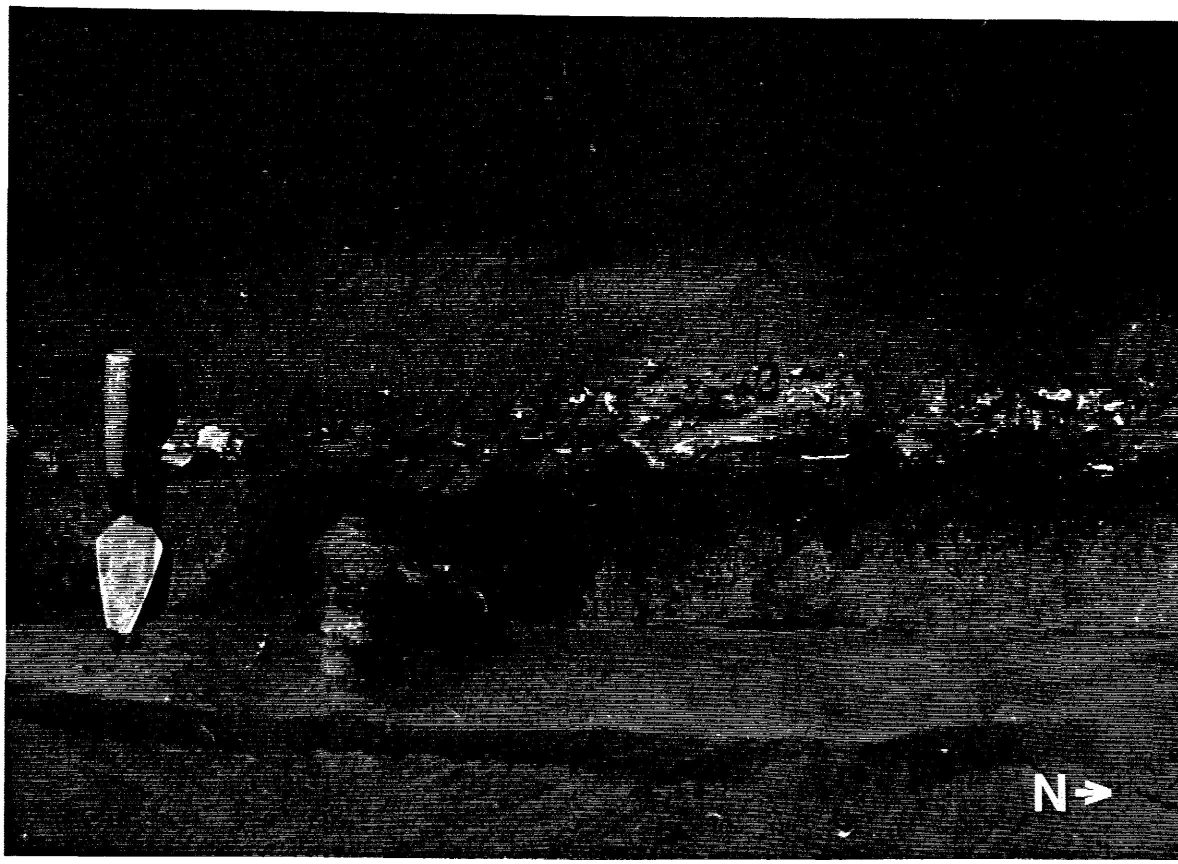


FIGURE 38 Profile of hearth feature from the west wall of excavation Area A at the Norby site.

that crania were being broken open so that brains and tongues could be extracted and subsequently cooked. This, of course, is conjectural and, without the direct association of an anvil stone, is difficult to substantiate to any degree. On the other hand, indirect evidence may be provided by the fact that the only anvil-maul recovered at the Norby site was directly associated with an extremely crushed crania.

In addition to the hearth feature in Area A there were two small burn features uncovered during excavation of Area B. The first, located in the central part of Area B, was not only a burn feature but contained extremely fragmented bone and was associated with two crania as well. This is a similar situation to that of the hearth feature in Area A and, therefore, it is possible that similar processing activities were being carried out in both areas.

The second Area B feature, found in the southeast corner, consisted of a small concentration of darkly stained soil. Ash and/or bone fragments were not associated with it. It is very difficult, then, to speculate as to the function or purpose of such a feature.

6.4 Sex Determination

Over the years numerous studies have been carried out by archaeologists in an effort to determine sex ratios in mass bison kill sites. Since sexual dimorphism is particularly marked in modern bison and is reflected in size differences in bone (Duffield 1973; Speth 1983), it is assumed that these differences are also present in archaeological samples (Todd 1987: 157). The methods employed in distinguishing size differences in archaeological assemblages have ranged from skull (eg. Wilson 1974; Frison et al. 1976; Skinner and Klaisen 1947), mandible and molar teeth measurements (eg. Frison 1970, 1973, 1978; Frison et al. 1976; Kline and Cruz-Uribe 1984; Reher 1970, 1973, 1974; Wilson 1980) to various studies on appendicular skeletal elements (eg. Bedord 1974, 1978; Peterson and Hughes 1980; Todd 1987: Zeimens 1982).

Both cranial and post-cranial analyses have been completed for the Norby site assemblage. Due to the degree of fragmentation, however, sexing many of the bison elements was deemed impossible. For example, crania, which are considered the most reliable indicators of sex, were highly fragmented and therefore, could not be measured. On the other hand, it was possible to study selected upper and lower limb elements (distal humeri, radii and distal tibiae) using a combination of methods developed by Speth (1983) and Todd (1987) for fragmentary faunal remains. A number of other elements, including metapodials, calcanei, astragali, numerous other carpals and tarsals, and phalanges, were recovered in relatively good condition and therefore were analyzed in an effort to further substantiate the findings from the long bone study.

Measurements that were utilized in the study of metapodials were those developed by Bedord (1974, 1978); calcanei measurements are from Lorrain (1968); the remainder of carpal and tarsal measurements were those of Morlan (1989); phalangeal measurements were those of Roberts (1982); and the astragali analysis followed that of Zeimens and Zeimens (1974). All measurements and methodological techniques are presented in Appendix Two.

6.4.1 Long Bones

The largest problem encountered during the sexing of the Norby site long bones was having a large enough sample to produce meaningful results. Femora were almost completely broken by post-depositional processes, as were proximal humeri and proximal tibiae. The only measurable limb bones were distal humeri (N = 18), distal radii (N =15), proximal radii (N = 13) and distal tibiae (N = 18). Numbers (N) include both left and right elements as well as immature specimens.

Where possible, measurements were taken on elements which had been reassembled. This was done only when bone had not been broken prior to that caused by excavation; these freshly broken bones were easily glued back together and allowed for sufficiently accurate measurements to be taken. In some cases, estimates were made on broken specimens but these measurements are clearly indicated by asterisks wherever they appear in the text.

Eight measurements were taken for distal humeri; six of these were developed by Speth (1983) for the Garnsey site bison study, and the remaining two by Todd (1987) for the Horner site. Both measurement techniques were designed to "aid in sexing damaged or fragmentary limb elements ... using material from modern bison (Bison bison) of known sex" (Speth 1983: 171).

Upon completion of the humeri measurements it quickly became apparent that, in comparison to those values recorded for the Garnsey site (Speth 1983), the Norby site elements are larger. In fact, when various measurements are plotted against each other on bivariate graphs, the Norby site clusters always fall in and above that interpreted as the male cluster for the Garnsey site Bison bison individuals. This suggests that a larger extinct species may be present. Bivariate graphs for various measurements can be found in Appendix 2.

The picture became clearer when measurement H1 and H7 were taken and compared to results and graphs from the Horner (Todd 1987) and Finley sites (Hapsel and Frison 1987), which represent older Paleoindian collections. In the majority of cases, the mean values for measurements H7 and H8 were similar to those from the Horner and Finley site bison remains (see Table 11). When plotted on a graph, the Norby site elements fell into or slightly below the male cluster for the extinct bison species recovered from these Paleoindian sites (Figure 39).

One of the biggest problems encountered when comparing the Norby site humeri, and long bones in general, to other site assemblages was that there were only eight points that could be plotted on a graph (MNI = 4) for the Norby site remains. The remaining nine specimens were not complete enough for most measurements to be taken, the most important being measurement H7. The same problem was detected during study of the Horner site material. Todd (1987: 162), however, states that

> ... the bivariate plots showing clustering along two dimensions can provide a basis for estimating the sex of damaged bones ... This gives a good indication of where to expect a difference between the sizes of males and females to occur on univariate histogram, which can illustrate all elements for which only the HM7 [Norby site's H1] measurement could be taken ... The procedure can be repeated for the HM11 [Norby site's H7] measurements ... Once most of a group of elements have been classified by sex, ranges of minimum and maximum values and standard deviations of the means can be used to estimate the sex of elements for which neither of the primary measurements can be taken.

Using this logic, an additional five Norby site specimens (3B-33, 5B-1, 19B-32, 8B-43 and 10B-14) are thought to represent male bison. This brings the number of males to fourteen (88%) out of a possible sixteen elements.

The results for the distal tibiae and proximal radii bivariate graphs are similar to that reached from the study of humeri. For all of the measurements developed by Speth (1983)

TABLE 11 Comparisons of select measurements from the Norby site to the Horner and Finley sites. The entire population of mature animals was used in the calculation of values. (Descriptions of measurements can be found in Appendix Two).

Measurement	No.	Min	Max	Mean
H1				
Norby	14	88	100	96
Horner	23	80	103	98
Finley	46	82	106	92
H7				
Norby	7	100	111	105
Horner	22	86	118	101
Finley	33	87	120	106
H8				
Norby	14	43	49	47
Horner	24	39	52	45
Finley	46	39	52	46
R3				
Norby	8	31	34	32
Horner	36	27	40	33
Finley	70	28	62	36
R6				
Norby	8	88	100	95
Horner	36	82	112	91
Finley	73	82	107	96
R7				
Norby	7	47	54	51
Horner	37	45	54	52
Finley	81	36	65	53
T1				
Norby	14	73	84	80
Finley	20	63	85	77
T2				
Norby	14	52	59	56
Finley	19	46	66	57

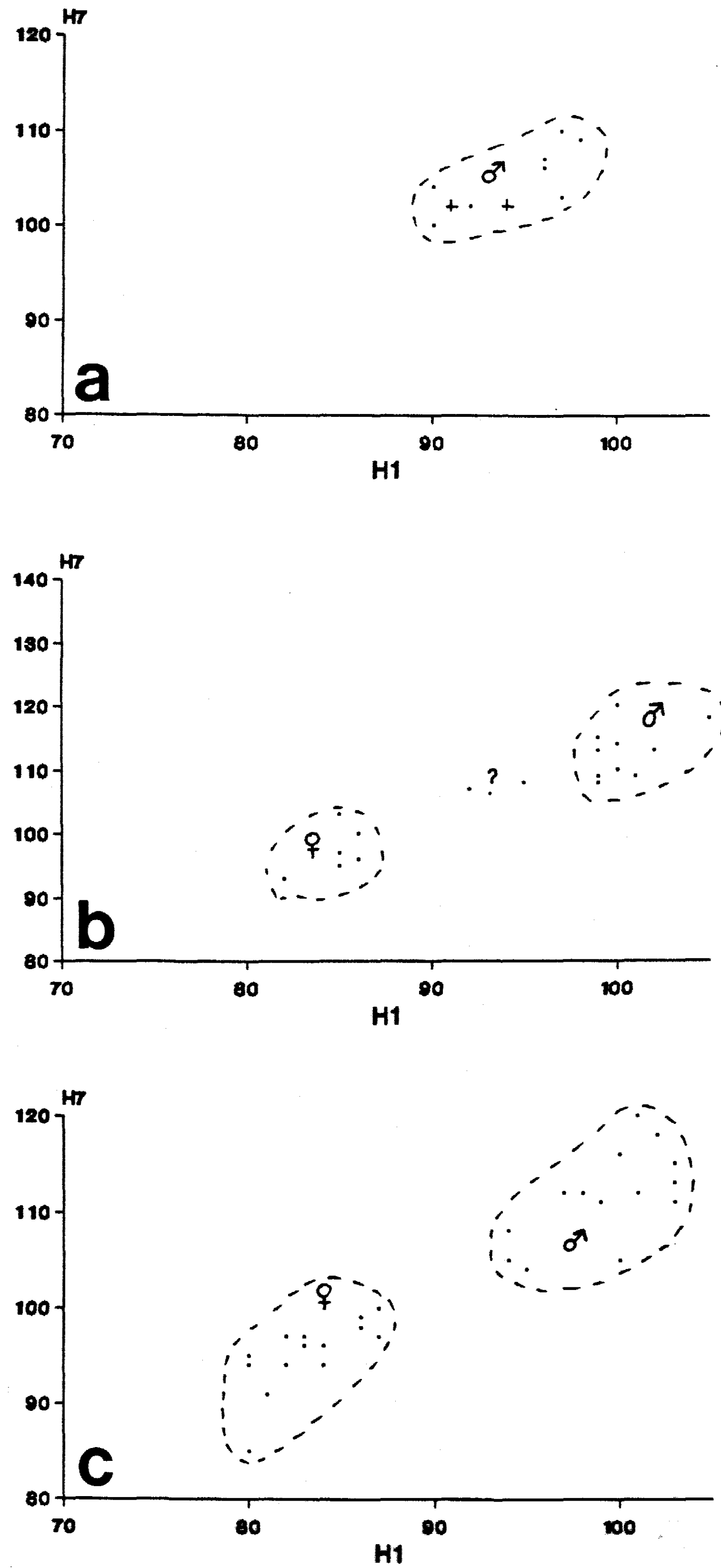


FIGURE 39 Bivariate scatters to compare humeri measurements from the Norby (a), Horner (b) and Finley (c) sites.

and applied to the Garnsey site bison, bivariate plots show the Norby site elements clustering in and above the male clusters for that Late Prehistoric site. With the tibiae, however, there did appear to be one specimen that was female (See Appendix 2, Figure A2.19).

Some discrepancies did arise when Todd's (1987) radii measurements were graphed. For instance, one set of proximal radii measurements (R7) were analogous to those from the Horner and Finley sites but the second measurement utilized (R6) had slightly lower values. As a result, when the measurements are plotted against one another, the Norby site male cluster falls under that for the Horner site males yet still remains consistent with the Finley site graphs (Figure 41). Almost every mature proximal radius from the Norby site appears to represent a male animal.

The presence of one cluster is a common pattern in the Norby site bivariate graphs. In most cases, the measurements taken for the Norby site faunal remains did not separate into two groups. For the largest sample, distal tibiae, all (MNI = 10) of the mature specimens, except one, fell into the male zone. If the four immature specimens of unknown sex are to be included, the resultant male/female percentiles derived from distal tibiae measurements are as follows: 76% male (N = 12), 6% female (N = 1) and 18% of unknown sex (N = 4) (Figure 40).

Distal radii show slightly lower percent values due to the lack of distinct clustering of the specimens. Even when

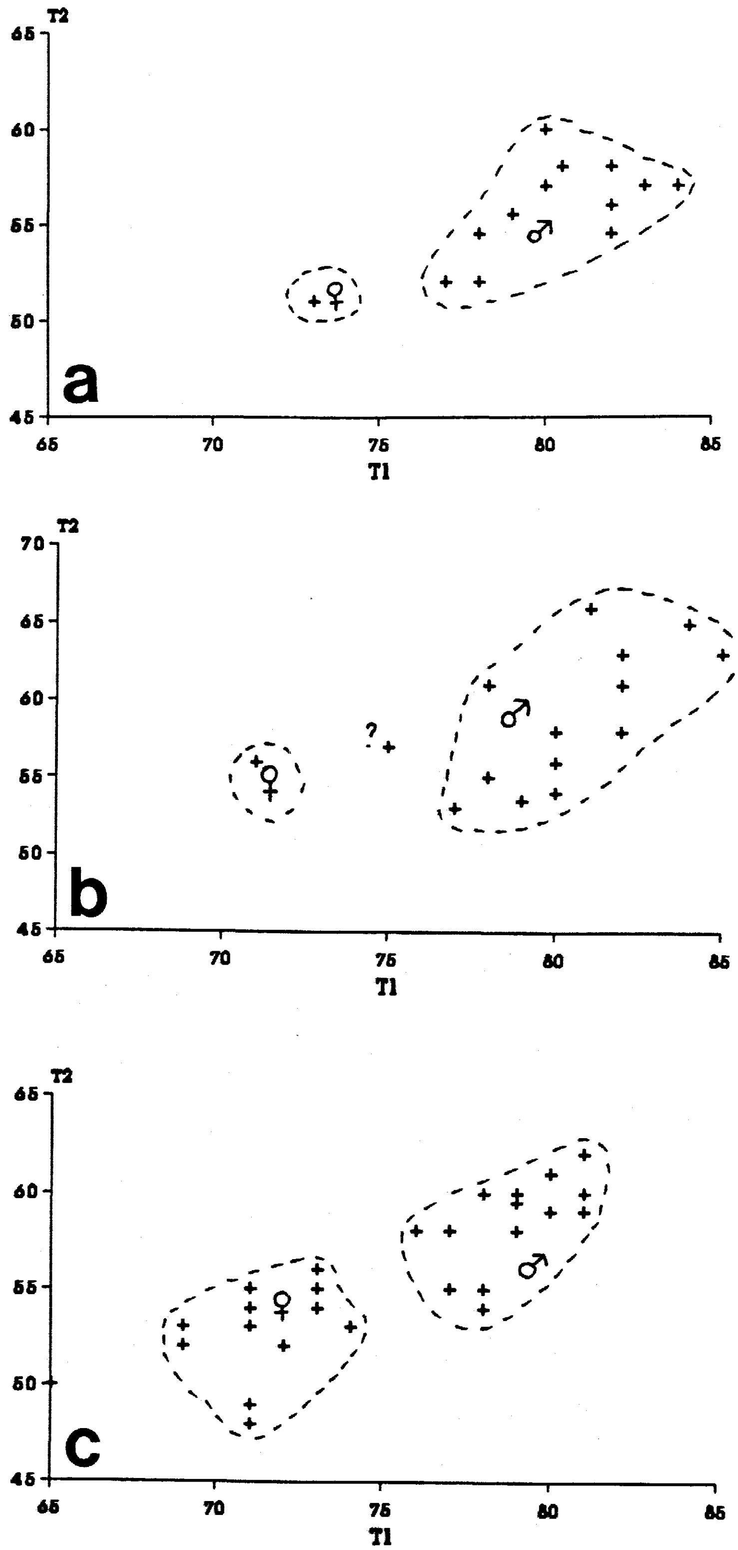


FIGURE 40 Bivariate scatters comparing tibiae from the Norby (a), Horner (b) and Finley (c) sites.

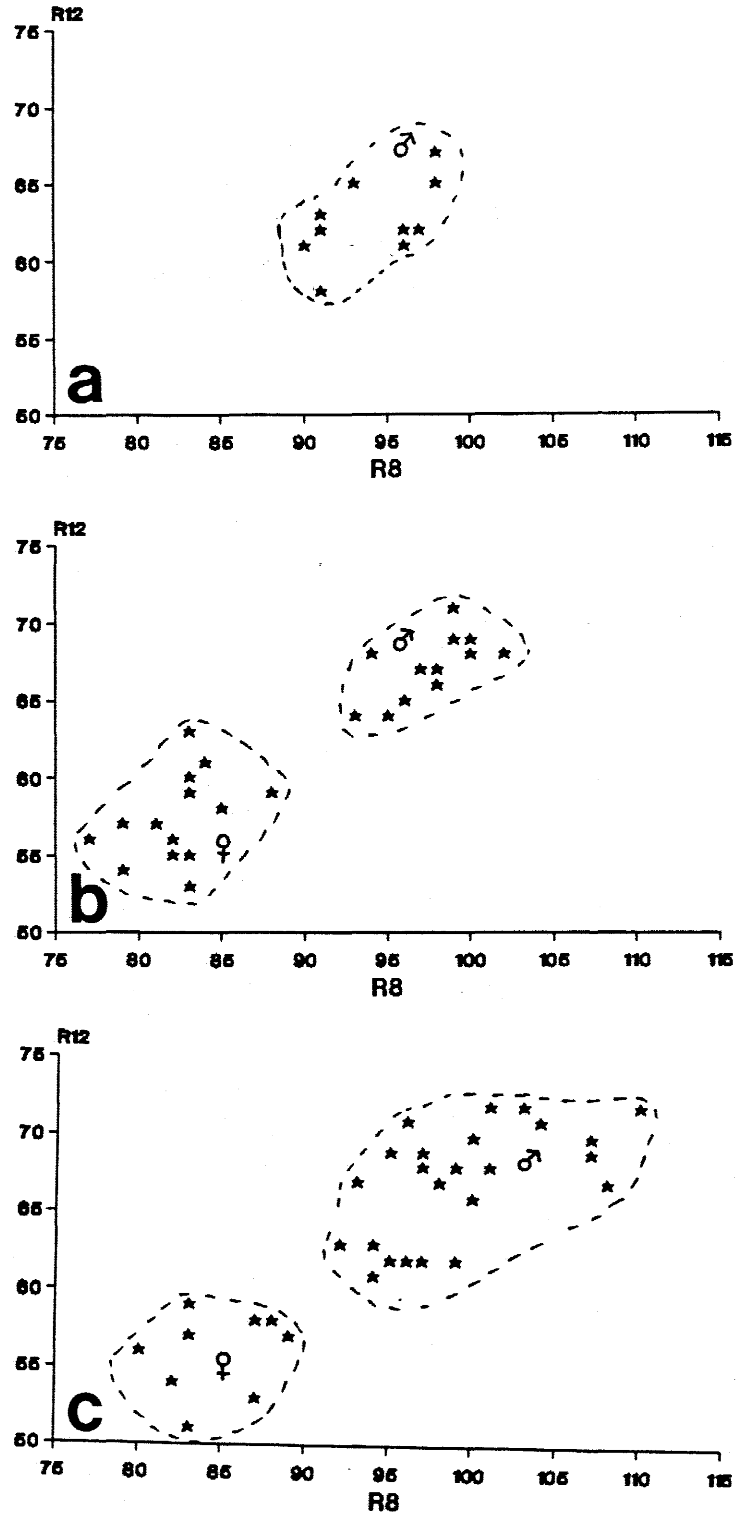


FIGURE 41 Bivariate scatters comparing proximal radii from Norby (a), Horner (b) and Finley (c).

compared to the Horner and Finley site graphs, it is extremely difficult to determine male or female individuals. The graph has, however, been interpreted as follows: 90% of the mature specimens clearly appear to be male (N = 9) and one individual female or an immature male (Figure 42). These results are comparable to those for the proximal radii where eight males (64%), 1 female (5%) and 4 (31%) immature individuals of unknown sex were concluded to be present (Figure 41).

If only mature specimens are taken into account, long bone measurements tend to agree that there is a preponderance of male animals in the Norby site assemblage. And, when measurements are compared to those from other sites, it becomes apparent that these animals appear to be members of an extinct species, or at least one in transition to the modern forms of bison.

Archaeologists commonly agree that bison diminished in body size throughout Holocene prehistory. Horn core and limb bone measurements do suggest a definite size difference between extinct forms (<u>Bison bison antiquus</u>) of 11 000 years ago and modern forms (<u>Bison bison bison</u>) of about 5 000 year ago to the present time. Transitional between the two, in size and age, is a second extinct form known as <u>Bison bison occidentalis</u>. These are Wilson's (1974, 1978) taxonomic designations for fossil and modern bison, in which he separates all forms on the subspecies level. In his opinion, to designate them as separate species would:

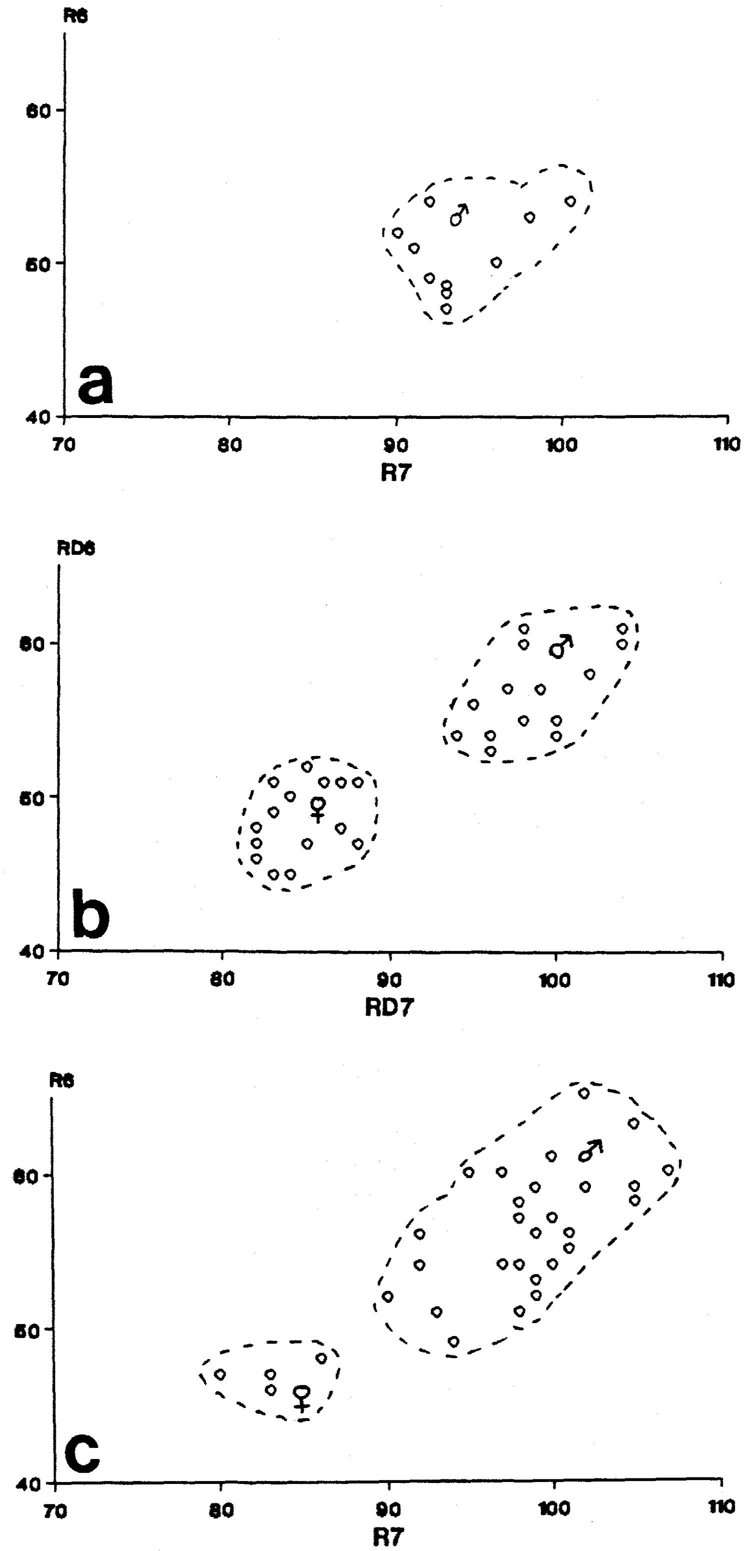


FIGURE 42 Bivariate plots comparing distal radii from the Norby (a), Horner (b) and Finley (c) sites.

> ... go hand-in-hand with a view that the two did not interbreed, and that there was no morphological overlap. Neither assumption seems to hold up in the face of evidence now available (Wilson 1978: 9-10).

Not all researchers approve of Wilson's designations. For example, McDonald (1981) feels that although occidentalis can be classified as a subspecies of B. antiquus, it should be kept as a separate species from that of modern bison. Several factors are provided to support his position, including the following:

> ... B. a. antiquus and B. a. occidentalis were apparently contemporaneous during much of the transition period (ca. 11,000-5,000 BP). B. a. occidentalis apparently represented regional populations of the species; populations that first appeared in the west ... whereas B. a. antiquus shifted northward, surviving in decreasing proportions as the transition period proceeded ... Character size in B. a. occidentalis was clearly nearer that of B. a. antiquus than of B. b. bison. **This combination of factors suggests that B. a. occidentalis should be considered a highly variable subspecies of B. antiquus (with which it apparently coexisted), not B. bison (which did not then exist), possessing a distinct range and responding multi- directionally to a newly ordered selection regime** (McDonald 1981: 258-259, emphasis added).

Because the archaeological record can be interpreted in such a way that it would provide support for either taxonomic position, the debate continues. However, most researchers do agree on the transitional nature of Bison occidentalis, especially in terms of size. When the Norby site bison are considered from a taxonomic perspective, the transitional nature of the remains immediately presents itself. Since the Norby site long bone measurements cluster into and above the groups for _B_. _bison_ males, and because they also cluster into and below that for male _B_. _antiquus_, it seems probable that they are male individuals of _B_. _b_. _occidentalis_ (or _B_. _a_. _occidentalis_). The absence of preserved horn cores, along with the small sample of the long bones does, however, severely limit any further attempts to substantiate such an hypothesis.

6.4.2 Metapodials

Both univariate and multivariate analyses were carried out for the metapodials, employing thirteen measurements designed by Bedord (1974) for study of the Casper site fauna. For the univariate study, the values for the Norby site bone were compared to those from the Casper, Hawken and Finley sites' extinct bison populations. In comparison to the Casper site herd, which was interpreted as a cow/calf herd, the Norby site bison bone exhibited a somewhat larger range of measurements and an overall larger mean for each measurement (Tables 12 and 13). But when the Norby site is related to the Finley site, which was reported to have more males than females represented, the metapodial measurement results are extremely similar. As with the long bones, measurements for metapodials suggest that an extinct species could be represented at the Norby site and that the majority of these individuals are probably male.

TABLE 12 Comparisons of metatarsal measurements from the Norby, Casper, Hawken and Finley sites.

	Norby Site			Casper Site			Hawken Site			Finley Site		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
M1	250	285	270	242	276	261	236	279	252	253	284	269
M2	56	71	62	52	67	57	48	64	57	52	67	60
M3	32	42	38	31	41	38	28	41	34	32	47	39
M4	63	78	72	63	79	69	57	73	66	60	79	71
M5	32	41	37	31	42	34	28	38	34	31	41	37
M6	55	63	58	48	61	55	47	59	53	51	63	57
M8	38	45	40	33	46	40	33	43	38	36	46	41
M9	30	34	32	27	35	31	27	33	30	28	35	32
M10	31	40	33	30	40	34	27	40	33	30	44	36
M11	213	237	228	205	236	222	198	223	216	216	237	227
M12	185	210	200	175	207	193	173	208	191	185	209	198
M13	187	210	202	182	214	196	175	208	193	189	210	200

TABLE 13 Comparisons of metacarpal measurements from the Norby, Casper, Hawken and Finley sites.

	Norby Site			Casper Site			Hawken Site			Finley Site		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
M1	199	222	214	200	224	213	200	222	210	201	230	215
M2	68	82	73	65	85	72	63	81	71	64	85	75
M3	45	54	47	36	55	43	33	53	43	32	54	46
M4	69	87	79	70	91	76	65	87	75	66	88	79
M5	28	34	31	26	35	30	24	35	29	24	37	31
M7	41	49	45	38	51	40	36	48	40	37	52	46
M8	35	44	41	34	46	40	35	43	39	36	46	41
M9	26	31	29	23	32	28	23	32	27	24	32	29
M10	45	53	48	36	56	43	33	53	42	36	54	46
M11	168	187	181	171	193	183	172	189	179	171	196	184
M12	150	170	161	145	169	159	150	166	156	145	170	161
M13	141	164	154	139	164	154	142	160	150	142	165	155

The results of the multivariate analysis were similarly surprising. Although Bedord (1974: 199-240) developed thirteen measurements for the examination of complete metapodials, she concluded that only four were able to adequately demonstrate sexual dimorphism in bison. These included:

M1	Maximum length
M2	Transverse width of proximal end
M3	Transverse width at center of shaft
M4	Transverse width of distal end

Bedord developed a ratio (M3/M1 x 100) that, when plotted on a graph against the fourth measurement (M4), resulted in obvious groupings. Clusters of the higher ratio values were thought to represent male individuals while lower value clusters were indictive of females. More specifically, Bedford (1974: 239) stated:

> ... for metacarpals, if measurement No. 4 is greater than (90 - 1/2 [Ratio 6]), then the bone is probably male, and if measurement No. 4 is less than (80 - 1/2 [Ratio 6]), then the bone is probably female. For metatarsals, the corresponding divisions would be as follows: if measurement No. 4 is greater than (76.5 - 1/3 [Ratio 6]), then the bone is probably male, and if measurement No. 4 is less than (67.5 -1/3 [Ratio 6]), the bone is probably female.

Despite the fact that the Norby sample is extremely small, with only sixteen metacarpals and fifteen metatarsals that could be analyzed using all of the possible measurements provided, the results from each set of measurements are comparable and therefore considered accurate in their determination of the sex of each element. Twelve of the Norby site metacarpals fall into the male range (Table 14) as defined

TABLE 14 Values for metacarpal Ratio 6 used in determining sex of individuals in bison kill sites (Bedord 1974).

SPECIMEN NUMBER	M4	90-1/2(R6)	80-1/2(R6)	MALE	FEMALE
11A-23	77.00	78.69	68.69	?	
9A-29	81.00	79.09	69.06	XY	
16B-35	81.00	79.40	69.40	XY	
8A-49	80.00	77.74	67.74	XY	
10B-90	76.00	79.10	69.10	?	
10B-17	84.00	78.26	68.26	XY	
11A-19	81.00	79.86	69.86	XY	
1A-8	80.00			XY?	
2D-32	79.00	78.67	68.67	XY	
15A-1	69.00				XX?
13A-72	77.00	78.44	68.44	?	
10B-21	77.50	78.86	68.86	?	
6D-25	82.50	77.47	67.47	XY	
10B-26	82.00	78.79	68.79	XY	
4An-29	79.50	79.77	69.77	XY?	
2A-29	80.00	78.97	68.97	XY	
19B-41	82.00	79.32	69.32	XY	
2D-1	81.00	79.11	69.11	XY	
15B-50	81.50			XY?	
8B-25	83.00			XY?	
2C-2	80.00			XY?	
6D-19	78.00			XY?	
15A-40	87.00			XY	
25B-29	70.00				XX?
9B-34	83.50			XY?	

? = unknown XY = male XY? = probable male
XX? = young male or mature female

TABLE 15 Values for metatarsal Ratio 6 used in determining sex of individuals in bison kill sites (Bedord 1974).

SPECIMEN NUMBER	M4	76.5-1/3(R6)	67.5-1/3(R6)	MALE	FEMALE
15A-37	77.00	71.83	62.83	XY	
6D-11	77.50	71.59	62.59	XY	
6A-44	72.50	71.74	62.74	XY	
16B-51	76.50	71.49	62.49	XY	
7A-20	75.00	71.88	62.88	XY	
1C-48	73.50	72.33	63.33	XY?	
2C-11	72.00	72.06	63.06	XY?	
7B-37	70.50	71.46	62.46	XY*	
11A-73	70.50	71.49	62.49	XY*	
5A-4	70.00	71.75	62.75	?	
7A-41	74.50	71.47	62.47	XY	
16B-78	73.60	71.41	62.41	XY	
1D-10	72.00	72.08	63.08	XY	
13A-45	72.00	72.60	63.60	XY	
16B-91	72.00	71.42	62.42	XY	
6A-38	68.50				XX?
9A-8	68.50				XX?
16B-52	75.00			XY?	
12B-36	73.00			XY?	
4C-45	69.00				XX?
4C-53	72.00			XY?	
6B-21	71.50			XY?	
9B-48	70.00				XX?
17B-10	62.50				XX?
7A-2	72.00			XY?	
14A-42	69.00				XX?
12A-32	67.00				XX?
4C-18	72.00			XY?	
10B-32	73.00			XY?	

? = unknown XY* = immature male XY = male
XY? = probable male XX? = young male or mature female

by Bedord. Four remaining specimens exhibit values that fall short of the male range but are still not low enough, using Bedord's equations, to be considered female; these could be young males. Six other metacarpals, for which Ratio 6 could not be calculated, are thought to be males. This supposition is based on the fact that their values for M4 fit closely into the size range as defined by those metacarpals that were able to be sexed using Ratio 6.

The results from the metatarsal analysis are similar. Fourteen metatarsals fall into the male range while one specimen falls just short of it. It was possible to make measurement No. 4 on an additional fourteen metatarsals; of these, fifty percent are probably male while the other fifty percent could have been young males or mature females. Because Ratio 6 could not be calculated however, the sex of these last mentioned metatarsals must, at best, remain hypothetical.

Overall, the analysis of metapodial measurements suggests a preponderance of males in the Norby site assemblage; the same conclusion that was arrived at using long bone measurements. The analysis of metatarsals suggests that 79% of the sample is male, 3% female and 18% are individuals that fall into the mid-range between male and female. In the same manner, metacarpal measurements attest to a herd composition of 76% males, 8% females and 16% individuals of unknown sex.

6.4.3 Calcanei

In the late 1960's Lorrain developed a set of measurements for the study of calcanei. The use of such measurements in the determination of bison sex is not a common practice in archaeological assemblage analyses. Hapsel and Frison (1987:490), however, found that two of Lorrain's (1968) measurements, transverse width of the proximal end and anterior-posterior width of the proximal end, clustered into fairly distinct groupings of size when plotted against each other on a graph. In light of these findings, a similar analyses was conducted on the Norby site calcanei.

A total of twenty-five calcanei were measured. Although both sides were utilized, immature specimens have been excluded from the study. When results were plotted on a graph, two distinct clusters were present. The largest cluster corresponds with the male cluster from the Finley site (Figure 43). Two other specimens, both right elements, fall into the female grouping. The ratio of males to females, using MNI numbers, is 14:2 or 7:1; 87% males and 13% females. Using the entire sample, the ratio increases to 23:2 or about 90% males and 10% females.

6.4.4 Other Tarsals and Carpals

In the past, carpals and tarsals have been largely ignored by those conducting bison population studies of

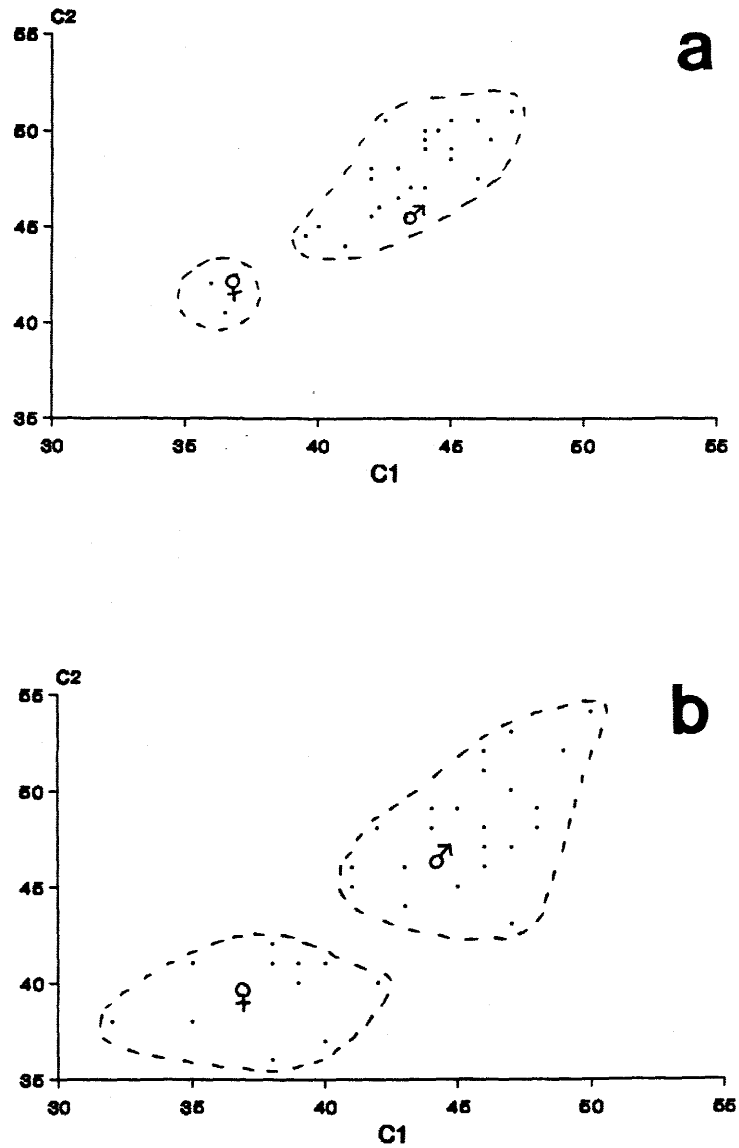


FIGURE 43 Norby site (a) and Finley site (b) calcanei measurements are compared. Distinct overlap of male clusters is evident.

archaeological assemblages; this is due to the fact that it is impossible to distinguish between mature and immature specimens. The only tarsal with an epiphysis that does not fuse early in life is the calcaneus and, for the Norby site, this element has been discussed previously. It appears to have been successful for sexing bison, not only in this study but at the Finley site as well.

An analysis has recently been carried out on a small sample of carpals and tarsals of Bison bison individuals from the Sjovold site (Morlan 1989). Morlan developed three measurements for each element and through bivariate graphs has interpreted bimodality in certain measurements as representative of male/female groupings. Although the Sjovold sample was small, this author was encouraged by the results of the study. With a larger sample, like that from the Norby site, it was anticipated that Morlan's preliminary conclusions could be strengthened.

A total of 491 carpals and tarsals were measured (Table 16). This included internal, unciform, accessory, ulnar and fused 2nd and 3rd carpals as well as the lateral malleolus, fused central and 4th and the fused 2nd and 3rd tarsals. Both right and left elements were included in a effort to further increase the sample size.

When final measurements were plotted, fairly distinct groupings were evident. Figure 44 shows the distinct clustering of the ulnar carpal. The remainder of the

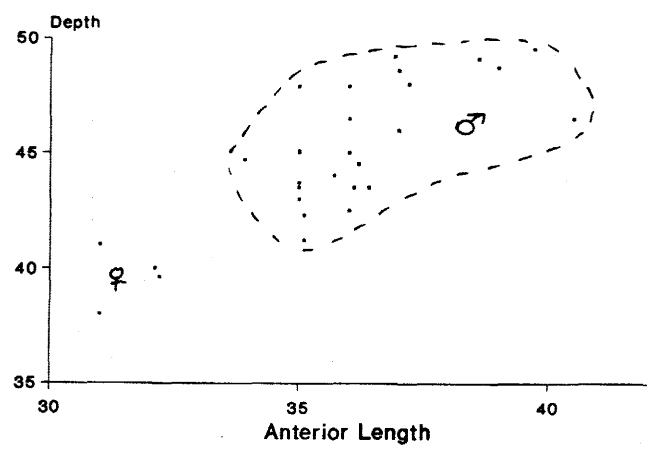


FIGURE 44 Bivariate graph showing clustering of ulnar carpal measurements into male and female groups.

bivariate graphs can be found in Appendix 2. In almost every case, there appears to be a large clustering of higher values, which correspond to that for the Sjovold males, and a scattering of points representing smaller specimens. Only the accessory carpal did not cluster into two groups (Figure 45); this carpal however, has the smallest number of specimens (N = 22) even when both the left and the right elements are included.

The results of the Norby site analysis are presented in Table 16. Female/male ratio are relatively consistent through

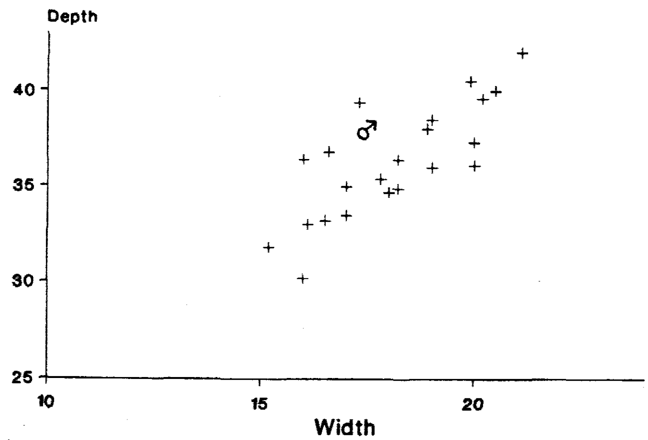


FIGURE 45 Bivariate graph of accessory carpal showing lack of distinct clustering.

TABLE 16 Ratio of males to females using Norby site carpals and tarsals.

CARPAL/ TARSAL	MEASUREMENT	FEMALE	UNKNOWN	MALE
Fused 2/3 Carpal	Width/Depth	6	--	25
Internal	Width/Length	2	--	26
	Width/Depth	3	--	26
	Depth/Length	2	1	26
Ulnar	Depth/Length	4	--	26
Unciform	Width/Length	5	--	32
	Width/Depth	3	1	32
Radial	Width/Length	5	--	38
	Width/Depth	6	--	38
	Depth/Length	5	--	38
Central and 4th	Width/Depth	4	5	33
Fused 2/3 Tarsal	Width/Depth	3	--	28
Lateral Malleolus	Width/Depth	4	--	19
	Width/Length	4	--	18
	Depth/Length	4	--	19

all the elements. On average, results indicate the presence of four (14%) females, or immature males, and twenty-seven (86%) males. These values also correspond to those arrived at by the analysis of metapodials (metatarsals - 79% male, 3% female; metacarpals - 76% male, 8% female) and calcanei (87% males and 13% female). Values for the long bone analysis are noticeably lower due to the presence of a larger number of immature specimens of unknown sex. When only mature specimens are included, the ratio for limb bones are considerably higher and tend to be more consistent with the other male/female percentages.

6.4.5 Astragali

The methods used to study astragali were the same as those set forth by Zeimens and Zeimens (1974) for the Casper site. Volume was the only measure recorded for the small Norby site sample (N=19), with only the right tarsal being subjected to the analysis.

In the original study of astragali, Zeimens and Zeimens state that

> ... The largest astragalus recorded is from the Casper site from which only three known males were recorded. the sample from the Finley site contained what is apparently more males so that a simple computation of means of the two site samples suggests that the Finley site animals were larger that those of the Casper site. This is an erroneous picture of the relative sizes of

> different sex and age groups with a population. <u>It is obvious from this that age and sex of the bones measured must first be known before analysis of this nature can provide meaningful statements concerning relative sizes of animals of the same age group from one site to the other</u> (1974: 246, emphasis added).

Ensuing investigators have, however, interpreted histograms of astragali volumes as representing not only the sex of certain individuals but the ages as well. For example, at the Agate Basin site, a quadrimodal distribution of volume measurements was subsequently interpreted as follows:

> The peak with the highest values probably represents older males; the next highest, younger males and robust females; another, near mature and mature females; and the lowest, immature animals of both sexes (Frison and Bradley 1982: 235).

There seems to be, at best, very little statistical basis for such a conclusion. The only conclusions that could be reached by such a study, especially since the bison remains from the Agate Basin site were extremely fragmented and could not be satisfactorily sexed using any other method, was that the Agate Basin astragali fell into a size gradient with the Casper, Olsen-Chubbock and Finley sites. Because these sites were all of similar time periods and involve extinct species of bison, the placing of the Agate Basin astragali in the size ranges of the aforementioned sites is only logical.

Keeping the cautions of Zeimens and Zeimens (1974) in mind, the Norby site astragali were initially related to other sites in terms of size, not sex and age. Like the Agate Basin tarsal, the Norby site specimens fall into the size ranges

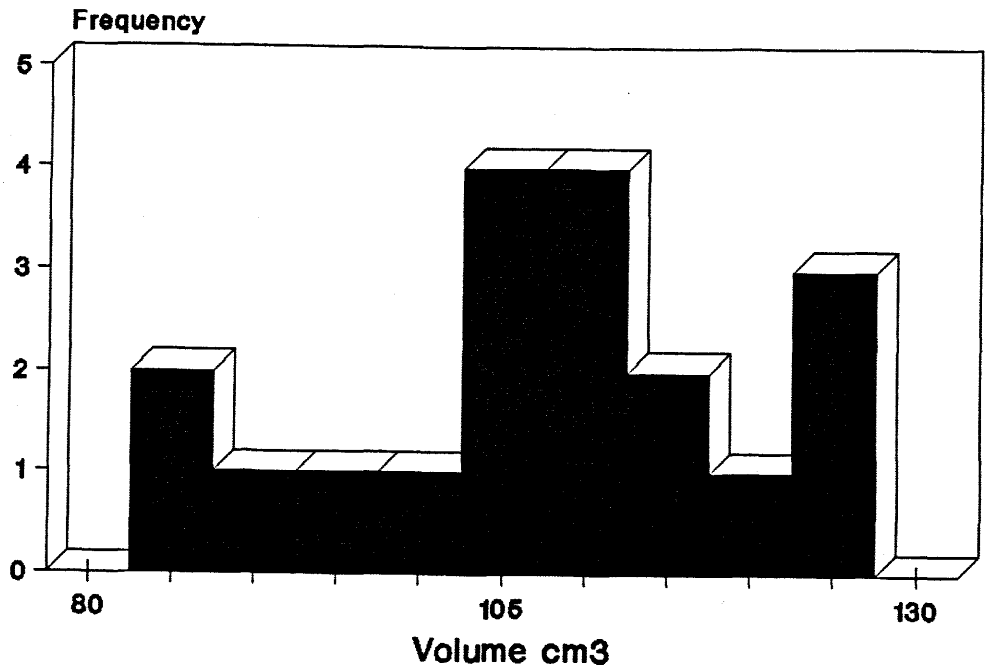


FIGURE 46 Histogram of astragali volumes recorded at the Norby site.

defined for the Casper, Olsen-Chubbock and Finley sites. The Norby astragali, reaching a maximum volume of 125 cm3, fall short of the values exhibited by the other sites which were 155 cm3 for the Casper site, 150 cm3 for Olsen-Chubbock and 140 cm3 for the Finley site.

In general, the astragali from the Norby site are large in comparison to those for Bison bison individuals. They do not, however, reach the extremely large sizes of the extinct bison forms. This may actually give some support to the suggestion that the Norby site bison are representatives of a transitional species, possibly B. b. occidentalis (or B. a. occidentalis).

Because the Norby site assemblage was amenable to sexing using alternative methods, and because these methods tended to agree in their results, this author feels that something can be said for the Norby site histogram that was formed by the astragali volumes. Taking into account the results of the metapodials, calcanei, other carpals and tarsals, and the long bone analyses, the Norby site trimodal distribution of astragali volumes (Figure 46) was tentatively interpreted as follows: the peak with the highest values could potentially represent mature males; the second peak, occurring at 105 to 110 cm3, could be that of younger males or mature females; and the final peak, at 85 cm3, immature animals of either sex.

6.4.6 Phalanges

The analysis and results of the bison phalanx study at the Norby site seem to be less reliable than that from the other sexing studies. Generally, the results tended to remain inconclusive as a means of distinguishing between males from females.

A total of 67 (MNI = 9) proximal anterior phalanges were measured. Five measurements were taken for each specimens; these included greatest length (P1), length (P2), proximal width (P3), distal width (P4) and distal height (P5). The descriptions of the measurements are presented in Appendix Two.

Only anterior phalanges were analyzed because, as noted by several archaeologists, posterior phalanges do not appear to reflect male/female size differences (Duffield 1973; Frison 1982a; Lorrain 1968; Roberts 1982). Two different studies, which employed some or all of the measurements listed above, were utilized for the Norby site materials. One of these was developed by Duffield (1973) and a second by Roberts (1982).

Initially, an index (P3/P1 x 100) designed by Duffield (1973) was calculated for the Norby site phalanges and plotted on a graph against P4 (distal width) measurements. Obvious groupings were not evident (Figure 47). The same problem is encountered by Roberts (1982: 61) during her analysis of Plains bison (B. b. bison) and she attributes this to the unreliable nature of the index. With the Norby material, however, a lack of clustering may simply reflect the fact that mostly males are represented by the phalanges. This would tend to agree with the results from long bone and metapodial measurements.

The second part of the phalanx analysis utilized what Roberts (1982:72) felt was an "effective discriminating equation" for discerning between males and female phalanges from archaeological sites. An equation was developed by Roberts, utilizing the Stepwise Discriminant Analysis (SDA)

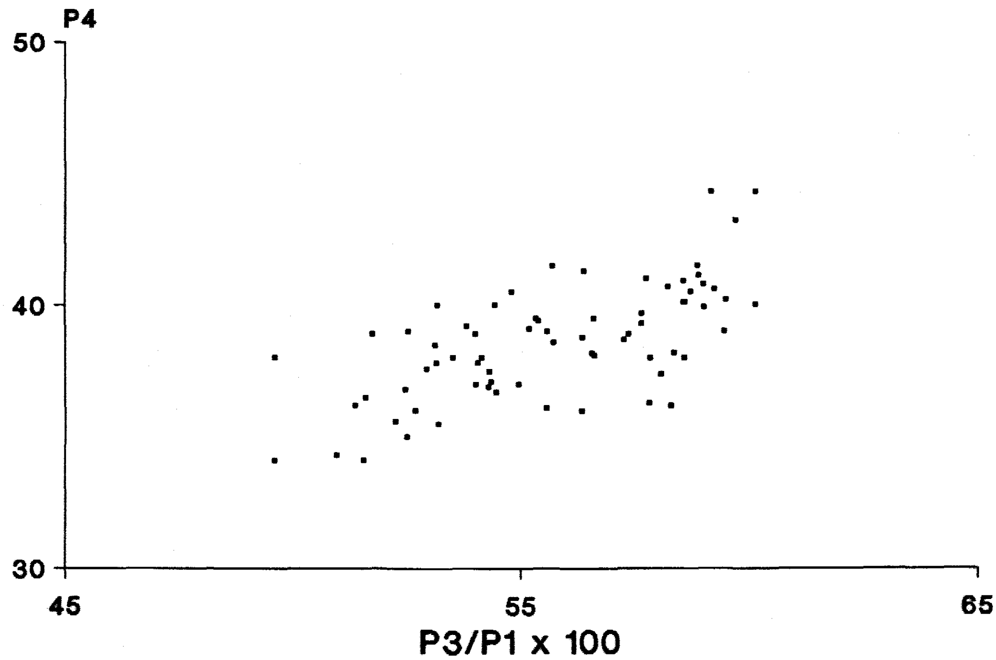


FIGURE 47 Bivariate plotting showing lack of clustering using Roberts (1982) methods.

computer program offered in the BMDP p-Series (Dixon and Brown 1979) in the following manner:

> Length, Greatest Length and Distal Height measurements ... were entered in the SDA program to compute a linear classification function. All previous attempts to using two measurements were unsuccessful ... The equation is as follows: function = (GL x .52067) + (DH x .54678) - (L x .29469)(Roberts 1982: 68-70).

However, Roberts (1982) warned other researchers about using her methods on collections older than 5000 years BP, stating that more work needed to be carried out and many more archaeological assemblages studied before conclusion could be reached. The Norby site, dating roughly to 5500 years, falls beyond the age range deemed suitable by Roberts. Nevertheless, an attempt was made to sex phalanges because they were one of the best preserved and well represented elements at the site.

The discriminating function was calculated for all the Norby site material and the results were plotted on a histogram. After plotting the values in the manner described by Roberts (1982: 70), a slight break was evident between the values 30.78 and 31.42 (Figure 48). These values are slightly higher than those defined for the populations studied by Roberts, which included the Elk Island National Park population (28.81 to 29.16), a museum collection of Plains bison from several area of Central North America (29.16 to 29.34) and the Stott site's Bison bison bison population (30.60 to 31.32). Roberts dismisses the differences between her values as such:

> ... to interpret the graph of the archaeological phalanges, the pattern of separation [on the histograms], rather than the statistical values ... was chosen to distinguish the sexes. ... it is likely incorrect to try to apply statistically a single value as the separation line to a population which has documented evidence of becoming smaller within the last 5000 years. As the patterned separation was so clear for the [other] samples it is expected that the same clear separation in a sufficiently large sample correctly divides the male and female adult phalanges (1982: 76-79).

According to the discriminant functions then, it appears that four out of the 67 phalanges could be female (Figure 49). This results in a female/male ratio to 1:14 or 6% females and 94% males.

In an effort to accommodate archaeological assemblage analysis, a second technique was developed by Roberts (1982)

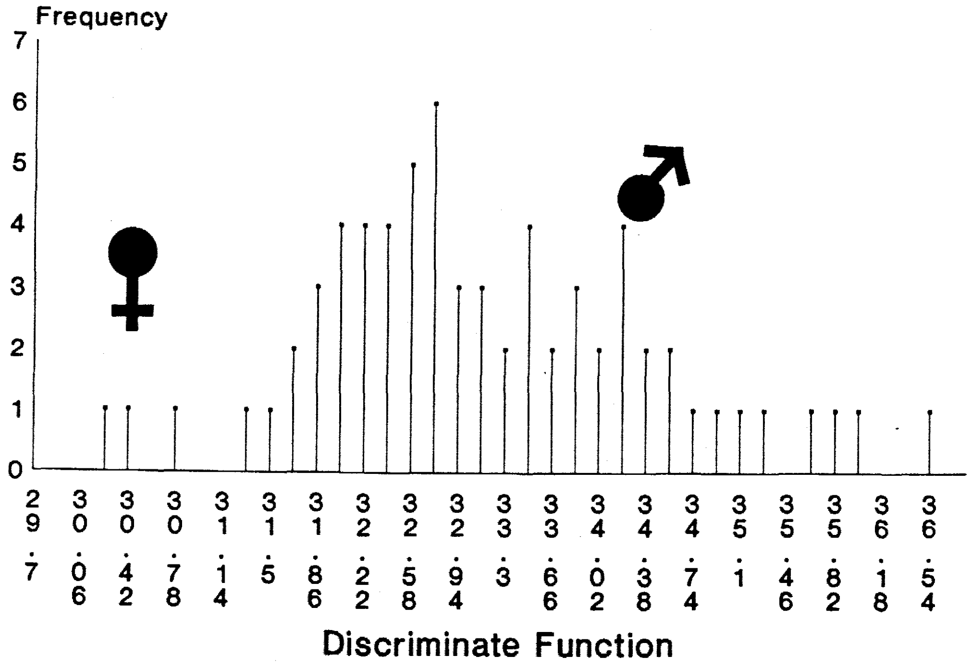


FIGURE 48 Histogram of Roberts (1982) discriminant function to frequency.

which employed only two measurements. In the end she found that the best bivariate scatter separation occurred when the transformation of Greatest Length (P1) X Distal Height (P5) was plotted against Greatest Length (Roberts 1982: 120). When this study was conducted using the measurement values from the Norby site the results were somewhat of a surprise. Again, clear, distinctive groupings did not appear. However, a slight gap seemed to be present which separated four of the specimens from the remaining 63. The ratio of males to females then, was 1:14 or 94% males to 6% females -- the same ratio was calculated using the discriminant function analysis. Because the two separate sexing techniques resulted in the

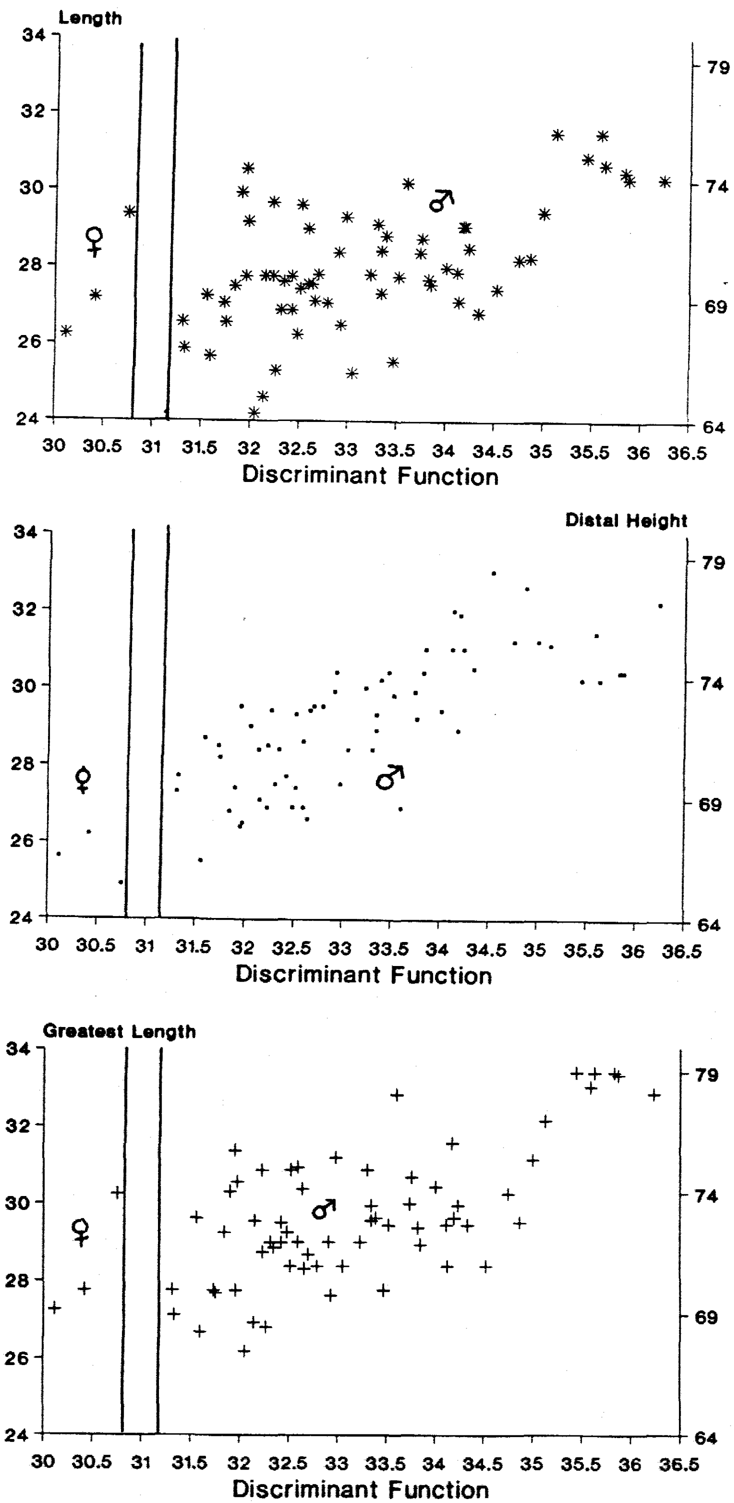


FIGURE 49 Discriminant function plotted against length, greatest length and distal height measurements. Graphs agree on the separation of three female specimens from the remaining sixty-three males at the Norby site.

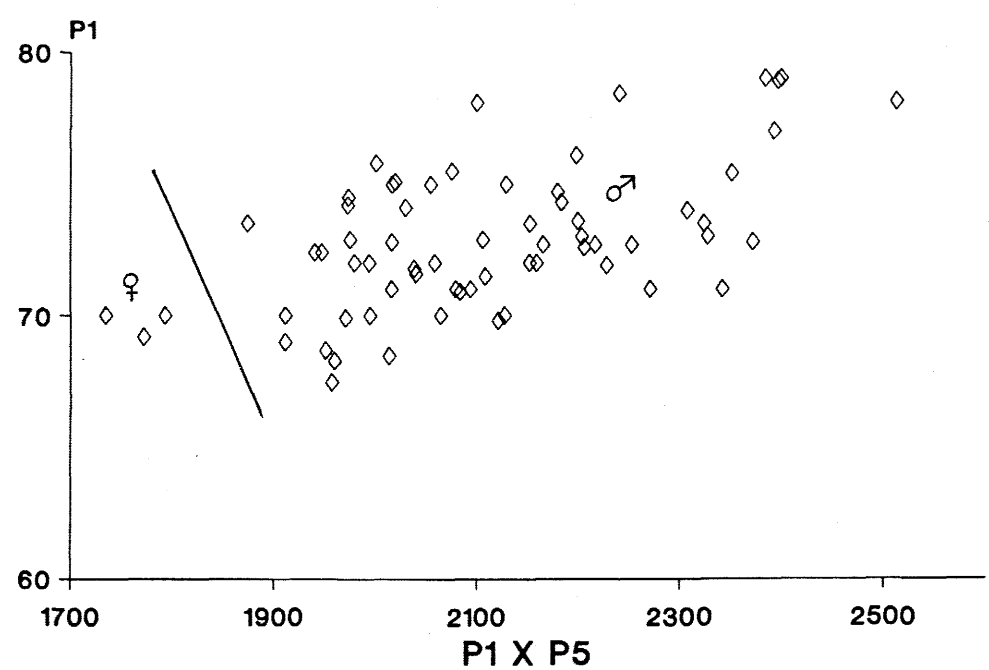


FIGURE 50 Second sexing technique of Robert (1982). It plots Greatest Length X Distal Height against Greatest Length.

resulted in the same values, and because these percentages compliment those derived from the study of long bones and metapodials, it appears that the phalange analysis, as designed by Roberts (1982), may be of some use in sexing bison assemblages dating over 5000 years BP. Caution, however, is advised to those attempting to make hasty conclusions in this regard until further studies are conducted.

6.4.7 Summary

The various methods utilized in the sexing of the Norby site assemblage all seem to agree on the domination of males at this kill site. Although the samples are small, the fact that the results from all the different analyses are similar lends support to such a conclusion.

6.5 Aging The Norby Site Dentitions

Aging bison dentitions has been used extensively by archaeologists over the years as a means for establishing the season of death at kill sites. Although young animals can be aged on tooth eruption schedules alone, aging older individuals requires special attention to wear patterns and more specifically, to enamel height as a measurement of wear. Such a technique was originally developed by Frison in 1978 for use on the Hawken site materials. Since that time, the method has been successfully applied to a number of prehistoric bone assemblages recovered throughout the Plains region (see Frison 1978, 1982a; Frison and Todd 1987; Frison and Reher 1970; Reher and Frison 1980; Reher 1970, 1973, 1974; Todd et al. 1990; Wilson 1974, 1980). This method was also employed in the analysis of the Norby site material.

6.5.1 Age Group Distributions: Mandibles

Aging the Norby site mandibles was not a simple task. A combination of poor preservation and small sample size were the cause of most of the difficulties. Even when both right and left mandibles were included, only seven complete or partially complete tooth rows, and twenty-two groups of loose teeth were present.

Mandibles were grouped initially by M1, M2 and M3 metaconid height measurements (Table 17). M3 measurements were then used in an analysis similar to that employed by Reher (1974) at the Casper site. When the metaconid heights for M3 are plotted on a graph, discrete age groups tended to cluster, creating a multimodal distribution (Figure 51). Group wear patterns were then compared to mandibles from several other bison kills (eg. Frison 1982a; Frison et. al 1976; Reher 1970, 1973, 1974; Peterson and Hughes 1980; Todd 1987; Todd and Hofman 1987; Wilson 1980). The dentitions at such sites have been previously aged using Frison's (1978) methodology. By relating the wear patterns and comparing age groups among several bison kills it was possible to determine the season of death for the animals at the Norby site.

The age groups for the mandibles at the Norby site, along with their distinctive wear patterns, are as follows:

<u>Group 1 to 3</u>: (0.7 - 2.75 years) No specimens available.

<u>Group 4</u>: (3.7 - 3.75 years) 3 specimens. All M3 cusps in wear including the hypoconulid; ectostylid barely visible above the alveoli, not visible on one specimen; strongly bilophodont. M2 ectostylid not in wear, still an average of

TABLE 17 Metaconid heights of the Norby site mandibular molars.

GROUP	AGE	CAT. #	SIDE	M1	M2	M3
4	3.7 - 3.75	1D-25	L	38*	57	64
		10B-5	L	35	56	63
		9B-3	L	32*	55	63
		X Group 4		35	56	63.5
5	4.7 - 4.75	3B-3**	L	--	--	58
6	5.7 - 5.75	3A-23	L	--	--	52
		18B-12	R	--	--	51
		5B-14	R	--	43	50
		2A-13	L	--	42	--
		4B-71	L	--	--	50
		1A-33	R	25	42	50
		7A-9	R	--	38	50
		1A-15	L	26	41	49
		5B-24	L	26	41	--
		5B-16	L	23	40	49
		24B-21	L	--	38	49
		12A-13	R	22	42	47
		X Group 6		24	41	50
7	6.7 - 6.75	12A-56	L	--	36	47
		3B-15	L	--	35*	45
		7B-1	R	--	--	48
		5B-4	R	--	33*	45
		2B-15	R	--	29	47
		13B-3	R	--	32	46
		15B-34	L	15*	31	45
		X Group 7		15	33	46
8	7.7 - 7.75	11A-39	R	--	--	42
		7A-10	L	--	30	41*
		9B-3	R	--	28	40
		X Group 8		--	29	41
9	8.7 - 8.75	1.3A-9	L	--	--	37
		5D-23	L	--	--	38
		2B-18	R	--	--	36
		X Group 9		--	--	37
10	9.7 - 9.75	15A-35	R	--	20*	30
		7B-49	R	--	17	27
		6B-67	L	--	--	28
		7B-42	L	--	--	26
		X Group 10		--	19	28

TABLE 17(cont.) Metaconid heights for Norby site mandibular molars.

GROUP	AGE	CAT. #	SIDE	M1	M2	M3
11	10.7 - 10.75	11B-80	L	12	13	21
		19B-24	R	11	--	--
		11B-79	R	--	11	19
		19B-25	L	--	11	19
		X Group 11		11.5	12	19
12	11.7 - 11.75	7B-50	R	--	9	--

* estimated measurement
** malformed M3

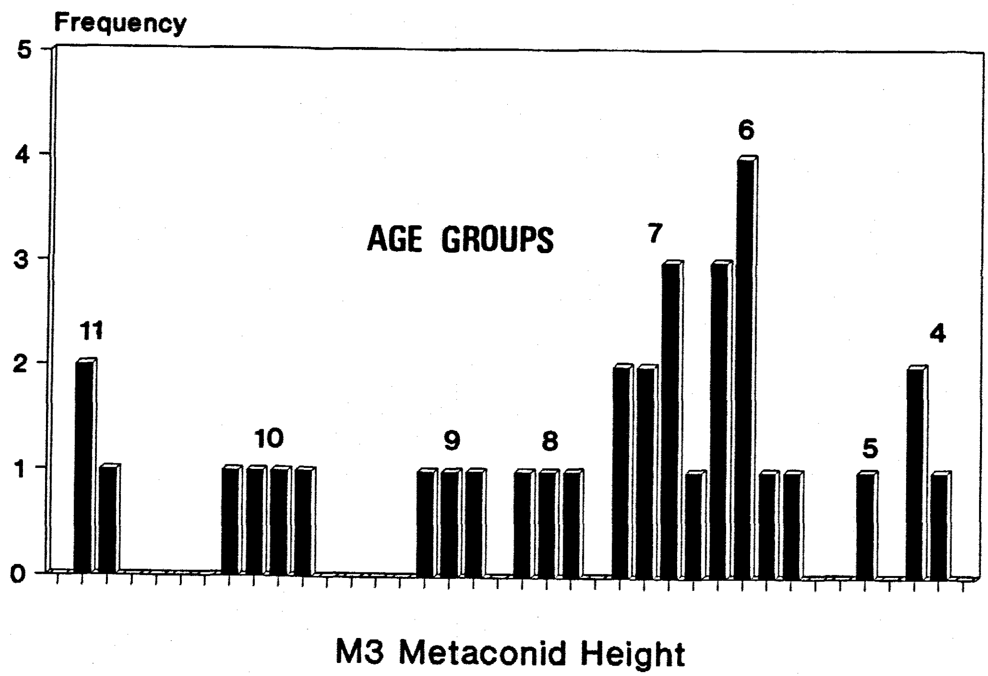


FIGURE 51 Measurement of metaconid height for determining age in a seasonally restricted sample.

4 mm below the main occlusal surface; strongly bilophodont. M1 strongly bilophodont; ectostylid forms a loop to join with main occlusal surface.

Group 5: (4.7 - 4.75 years) One M3 specimen available but since the tooth is deformed the wear pattern does not conform with the patterns that are present in the other groups. This tooth will be described later along with a number of other dental anomalies and pathologies.

Group 6: (5.7 - 5.75 years) 12 specimens. Wear on M3 ectostylid ranges from unworn (below main occlusal surface by 3 mm) to just coming into wear; tooth is strongly bilophodont in all specimens. M2 ectostylid is now in wear but forms a circle distinct from main occlusal surface; strongly to moderately bilophodont. M1 weakly bilophodont; ectostylid forms a loop to join with main occlusal surface.

Group 7: (6.7 - 6.75 years) 7 specimens. Wear on M3 ectostylid ranges from polished on tip to lightly worn into a small circle discrete from the rest of the occlusal surface; strongly bilophodont. M2 moderately to strongly bilophodont; ectostylid forms a loop to join with main occlusal surface; enamel base still below alveoli level on two almost complete specimens. The two M1 specimens from this group are highly variable. One tooth (5B-34) shows no cupping with strong pre-

FIGURE 52 Buccal (a) and occlusal (b) views of a partial mandible from the Norby site. 3.7-3.75 years.

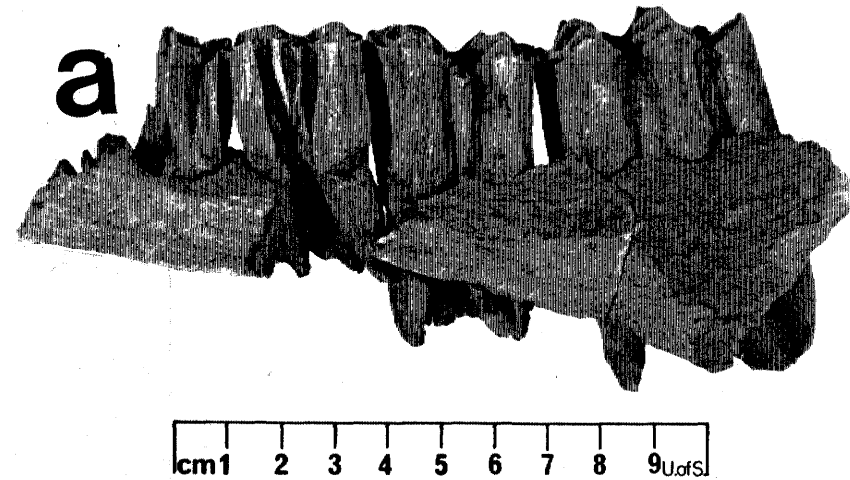
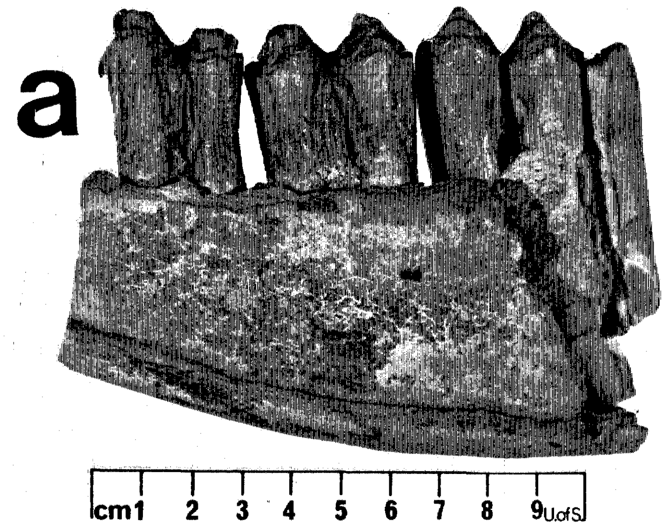
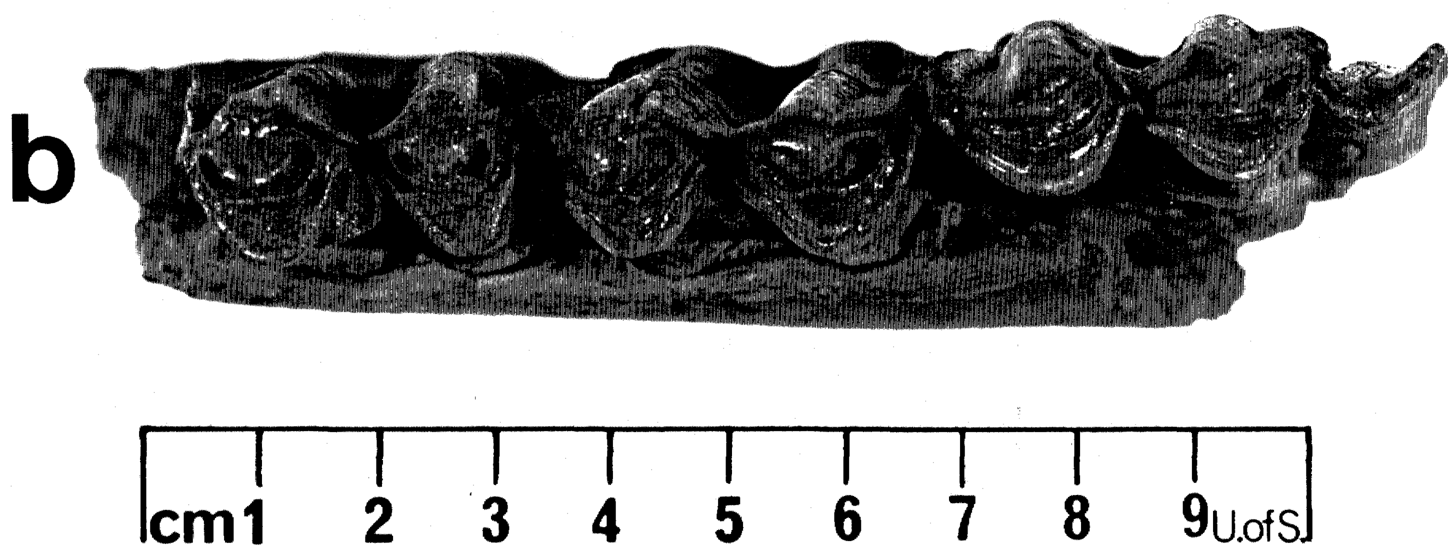


FIGURE 53 Mandible from a 5.7-5.75 year old animal recovered during the excavation of the Norby site. Buccal (a) and occlusal (b) views are shown.





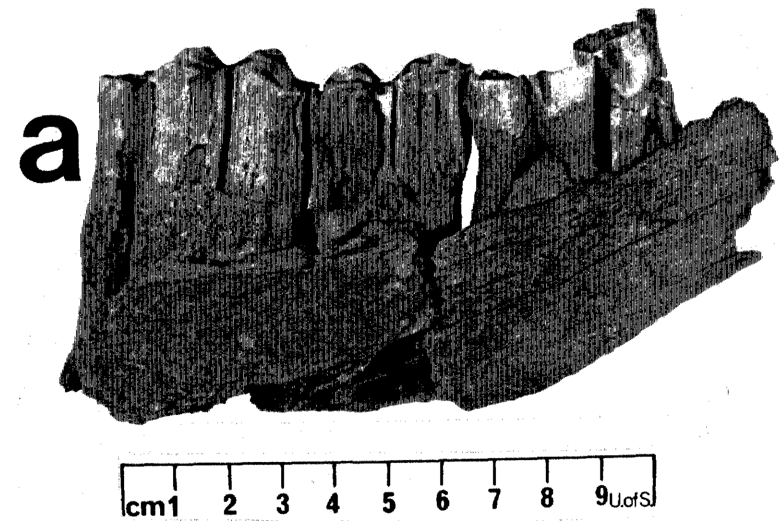
and postselenids while in the second (2B-15) the preselenid is beginning to cup out, prefossetid weakening and cupped and the postfossetid is still present but small and weak.

Group 8: (7.7 - 7.75 years) 3 specimens. Grouped by mainly by metaconid height of M3. Wear on M3 ectostylid forms an oval extending almost to join the main occlusal surface; moderately bilophodont. M2 is moderately to weakly bilophodont; ectostylid forms a loop to join with the main occlusal surface.

Group 9: (8.7 - 8.75 years) 3 specimens. Group membership based on metaconid height of M3. Wear patterns are similar to that seen in group 8.

Group 10: (9.7 - 9.75 years) 4 specimens. M3 ectostylid now forms a loop to join with main occlusal surface; moderately to weakly bilophodont. The hypoconulid on one specimen (7B-49) was worn in an unusual manner; although the metaconid height of M3 is normal for this group the hypoconulid was almost worn away. The loop formed by the M2 ectostylid and main occlusal surface is visibly smaller than that of the previous age group; weakly bilophodont; enamel base at level of alveolus. Only one M1 specimen and it was unusually worn in comparison to the M2 teeth present; both the preselenid and postselenid were absent; prefossetid and postfossetid deeply cupped.

FIGURE 54 A 6.8-6.9 years old individual from the Norby site. Buccal (a) and occlusal (b) views.



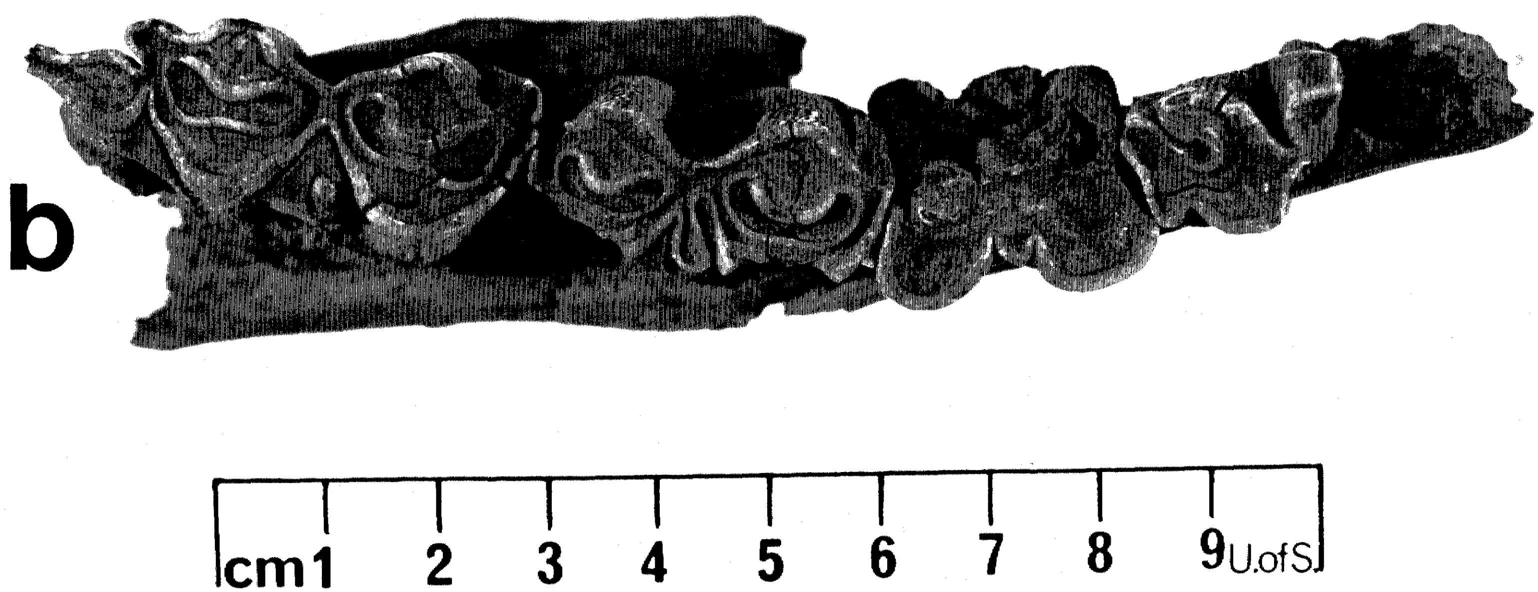
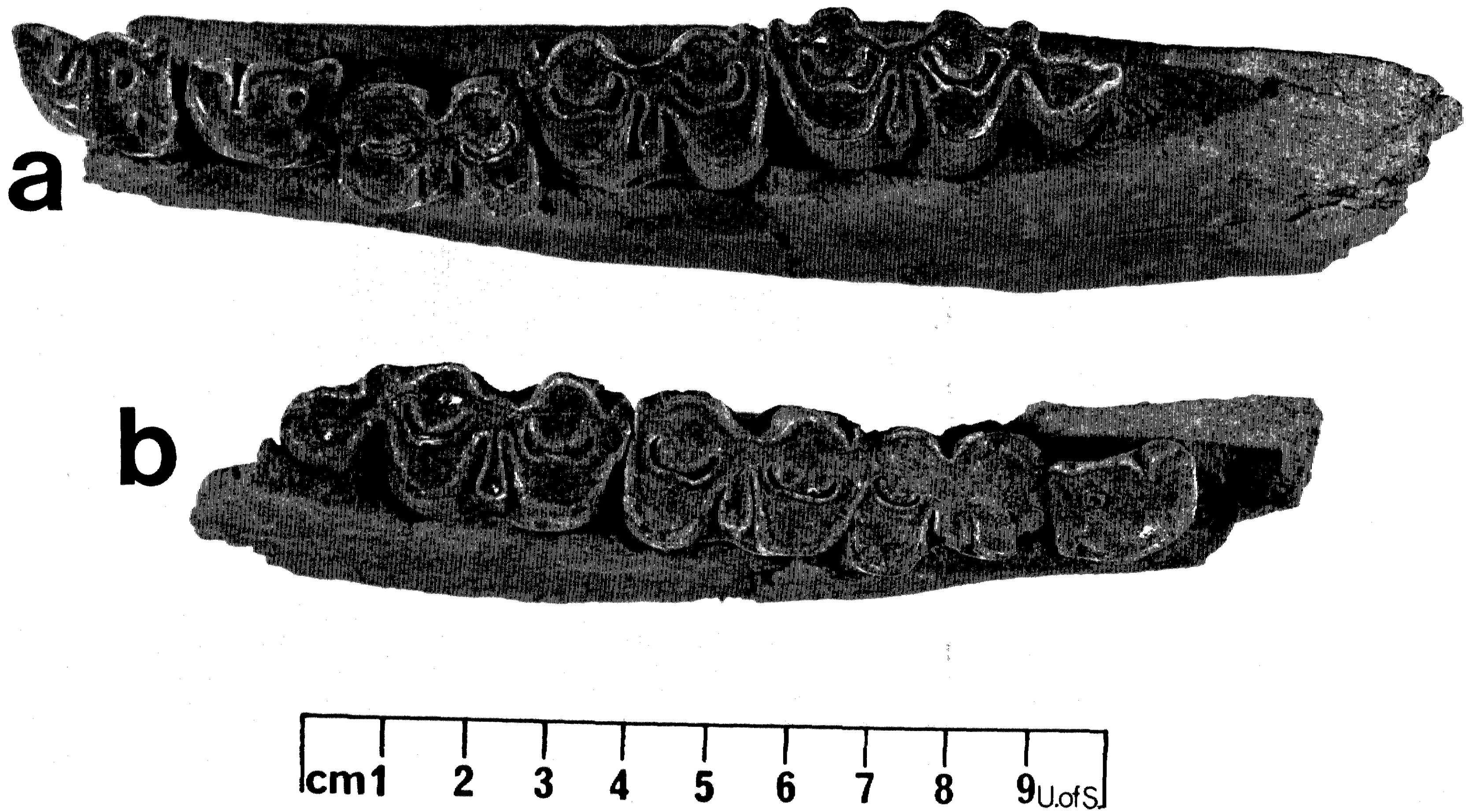


FIGURE 55 A right (a) and left (b) mandible from an 10.7-10.75 years old Norby site animal.



<u>Group 11</u>: (10.7 - 10.75 years) 4 specimens. M3 wear variable but generally tooth is very weakly bilophodont or worn flat; enamel base at or slightly above the level of the alveolus. M2 loop formed by the ectostylid and the main occlusal surface is more 'open' due to more wear; very weakly bilophodont to worn flat; enamel base above the level of alveolus. Only one M1 to examine; wear on the tooth was such that both the preselenid and postselenid, although small and weak, were present.

<u>Group 12</u>: (11.7 - 11.75 years) 1 specimen. Only one mandibular M2 represents this entire age class. The tooth was degenerated to the point where both the preselenid and the postselenid are absent and the tooth is extremely cupped.

When the results of this analysis are plotted on a graph, the distribution of individuals appears to be bimodal (Figure 56). However, it is most probable that this pattern is only a reflection of the use of both left and right specimens and the small size of the sample. In general, the relatively high percentage of "prime adult" animals is suggestive of a catastrophic rather than an attritional curve.

In an effort to more precisely define the season of death at the Norby site, wear patterns in each age group were compared to those evident at the Agate Basin (Frison 1982a), Hawken (Frison et al. 1976), Casper (Reher 1974) and Garnsey

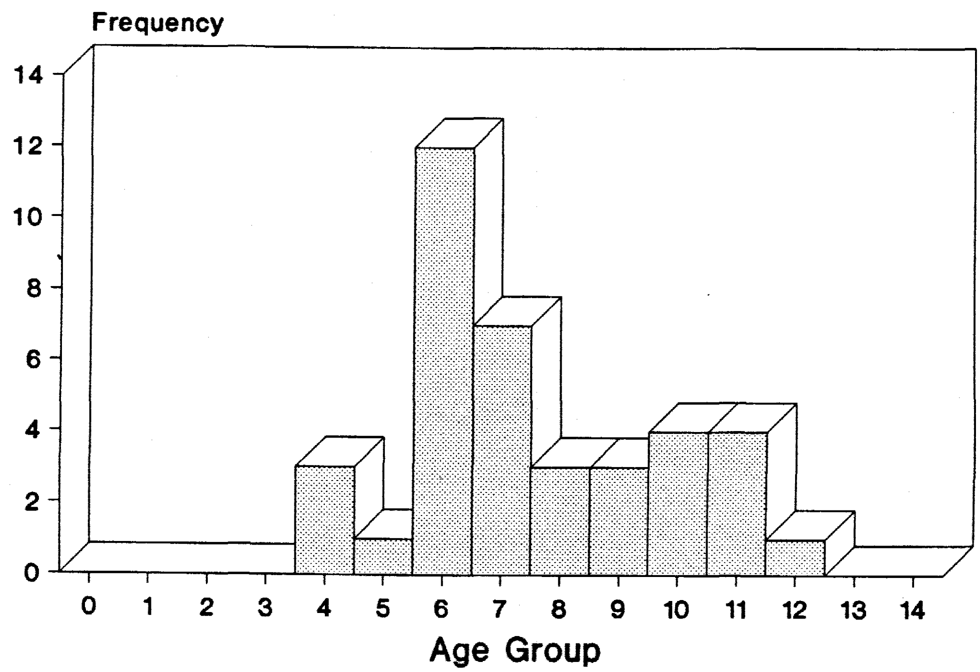


FIGURE 56 Age-group distribution of mandible-based individuals at the Norby site.

sites (Wilson 1980). It was then possible to determine that the season of death occurred approximately .7 to .75 years after the annual calving pulse. This conclusion was reached after a detailed comparison of M3 and M2 wear of the Norby site's Group 4 (3.7 - 3.75 years) was made to the Garnsey site's group 5 (4.0 years), the Hawken site's group 4 (3.7 years) and the Casper site's Group 4 (3.6 years). For example, at the Hawken site the hypoconulid of M3 is not in wear or is just coming into wear for the individuals in the fourth age group. In contrast, the Norby site mandibles, which are thought to be at least a month or two older, exhibit wear on all facets. At the Garnsey site, individuals that are four years old also exhibit wear on the hypoconulid. What distinguishes the Garnsey group as somewhat older than that of the Norby site is the fact that the ectostylid on M2 is already in wear in the Garnsey site's group 5. In the Norby site mandibles, the M2 ectostylid is still an average of 4 mm below the main occlusal surface. Similar comparisons can be drawn for a number of the other age groupings.

Overall it appears that the Norby site age groups conform most closely to those established for the Agate Basin site. Although Frison (1982) was only able to define age groups at the Agate Basin site to within a three month range, it is still possible to make some comparison between the two dental complexes, especially in regard to metaconid height.

Table 18 and 19 present the average annual enamel heights for all molar teeth in the age groups proposed for the Norby site and those for the Agate Basin site. Although the Agate Basin site mandibles pre-date the Norby site sample by at least 4000 years, there is a close similarity between the two sites in terms of tooth attrition rates. Frison states that the yearly annual attrition rate on M1's was 6.5 mm; on M2's, 6.0 mm; and 5.3 mm on M3's (Frison 1982: 250). Likewise, Norby site attrition rates have been assessed at 6.0 mm for M2's and 5.5 mm for M3's. A lack of complete specimens prevented a similar measurement being calculated for M1. At

TABLE 18 Age groups and metaconid height measurements for the Norby site.

AGE	AGE IN YEARS	NUMBER OF MEASURABLE SPECIMENS	AVERAGE ENAMEL HEIGHT M1	M2	M3
1	0.7 - 0.75	-	-	-	-
2	1.7 - 1.75	-	-	-	-
3	2.7 - 2.75	-	-	-	-
4	3.7 - 3.75	3	35	56	63
5	4.7 - 4.75	1	-	-	58
6	5.7 - 5.75	12	24	41	50
7	6.7 - 6.75	7	15	33	46
8	7.7 - 7.75	3	-	29	41
9	8.7 - 8.75	3	-	-	37
10	9.7 - 9.75	4	-	19	28
11	10.7 - 10.75	4	11	12	19
12	11.7 - 11.75	1	-	9	-

TABLE 19 Agate Basin average mandibular metaconid heights (millimetres). (Frison 1982a: 251)

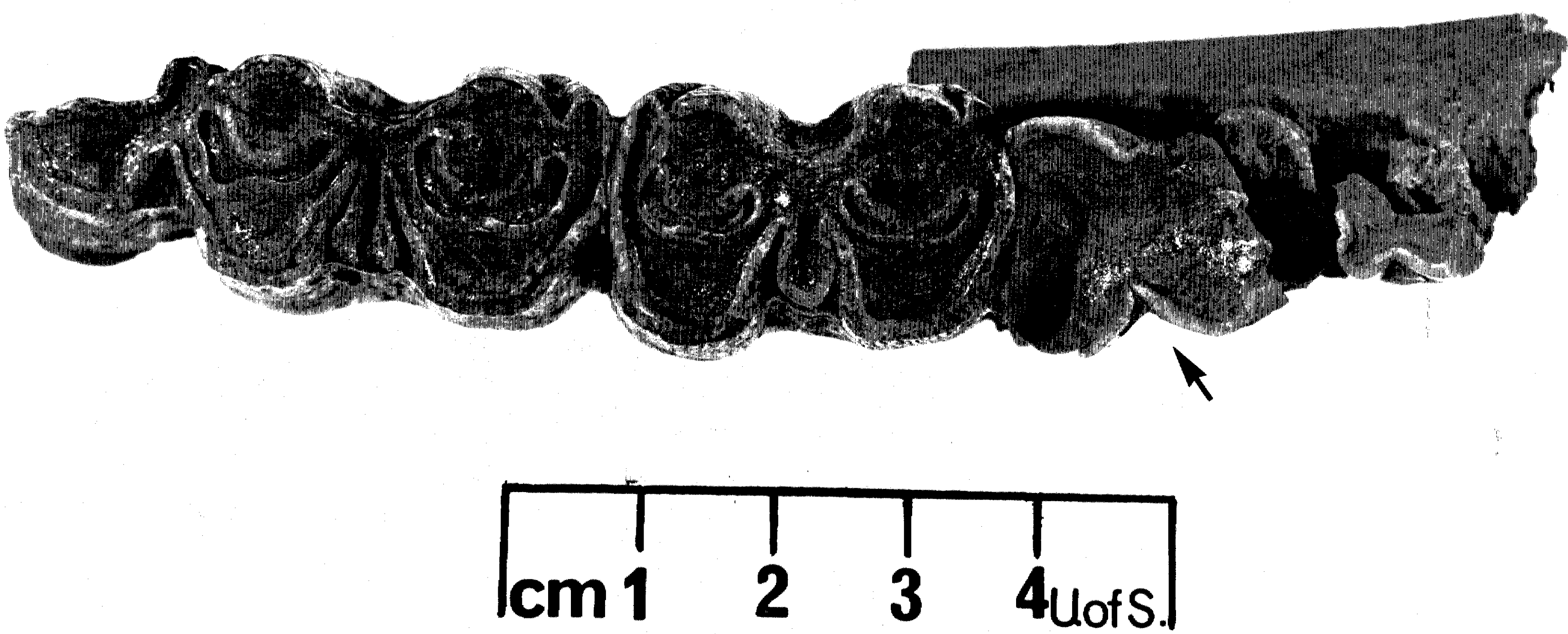
AGE GROUP	M1	M2	M3
1	55.3	--	--
2	50.2	69.2	--
3	42.3	60.6	68.1
4	39.5	58.0	65.6
5	30.3	49.9	58.4
6	23.5	41.8	53.8
7	16.1	32.1	46.9
8	18.0	32.0	41.5
9	--	11.5	35.5
10	--	--	--
11	--	--	25.0
12	--	9.0	20.0

any rate, these are fairly high rates of attrition in comparison to those of Late Prehistoric bison at the Glenrock and Wardell sites (Reher 1970, 1973) and indicate a shorter life span for Early Plains Archaic (Early Middle Prehistoric) bison. A similar conclusion was previously reached by Frison (1982: 251) in regard to the late Pleistocene-early Holocene bison from the Agate Basin site.

Stress, be it environmental or otherwise, is not only inferred by what appears to be a shorter lifespan, but also by dental irregularities that are present in the Norby site mandibles. Unusual tooth wear is present in three specimens. The M1 from individual 7B-49 exhibits extreme wear in comparison to that evident for its M2 (Figure 57). A second and third individual display uneven wear in that the anterior and medial crescents of the M3 stand above the hypoconulid (Figure 58). A similar phenomenon was observed in the Casper site mandibles (Wilson 1974: 167-169).

A fourth tooth recovered during excavation was found to be malformed (Figure 59). The crescents of the M3 of specimen 3B-3 are crowded causing the anterior loph to turn buccally. As a result the occlusal surface of the tooth is curved with the concave surface facing lingually. Wear on the tooth is also unusual due to this deformation. The hypoconulid and the posterior portion of the medial crescent are extremely worn in comparison to the wear on the anterior crescent. In addition, the lingual cusps are less worn than the buccal cusps creating

FIGURE 57 Mandible from a seven year old animal showing unusual wear on the first molar.



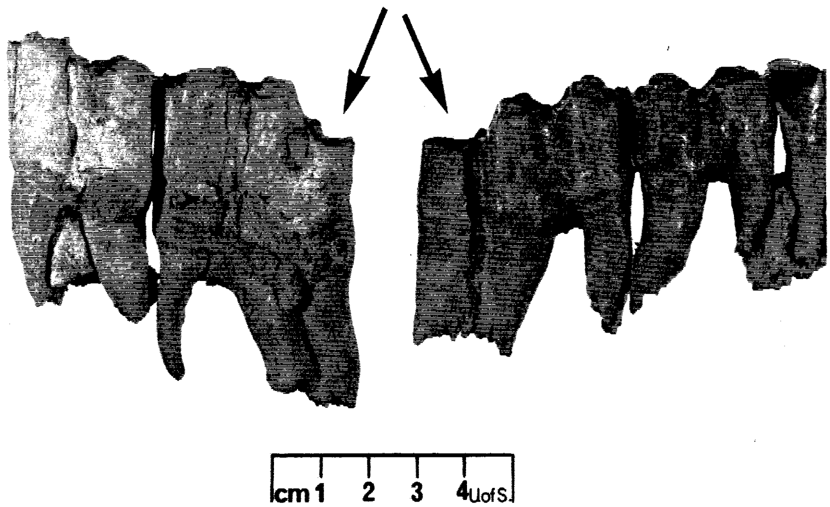


FIGURE 58 Uneven wear of hypoconulid in two specimens from the Norby site.

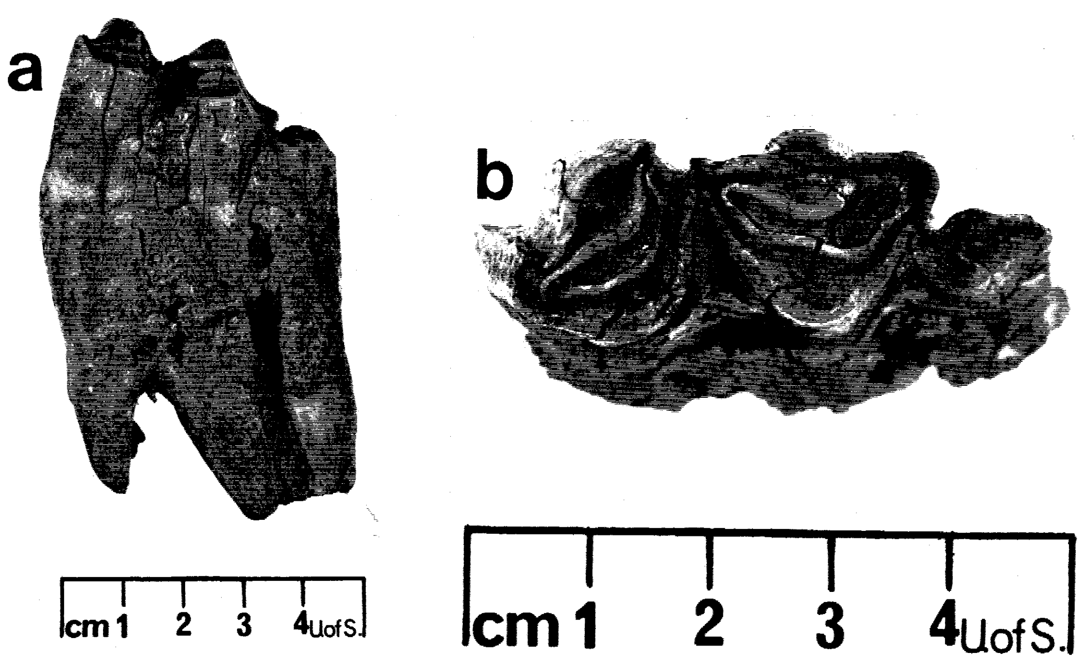


FIGURE 59 Buccal (a) and occlusal (b) views of a malformed tooth from the Norby site. Note the crowded cusps and uneven wear of hypoconulid.

a slant to the occlusal surface as a whole.

At the Casper site, Wilson (1974) suggested that environmental stress was probably the cause for several of the dental pathologies and peculiarities that were present. A similar suggestion could be offered as an explanation for the Norby site dental irregularities because the site does date to within the Altithermal period -- thought to be a time of warm temperatures and drought for the Plains region. Whatever the explanation, the high rates of tooth attrition evidenced in the Norby site mandibles suggest that the Early Plains Archaic (Early Middle Prehistoric) bison were undoubtedly undergoing some kind of stress that resulted in heavy, and in some cases, unusual tooth wear.

6.5.2 Age Group Distribution: Maxillae

Rarely is it the case that maxillae preserve well enough for an age analysis to be made; two classic examples are the Casper (Wilson 1974) and Garnsey (Wilson 1980) sites. The Norby site maxillae were completely disintegrated but several teeth were recovered. When paracone height measurements were taken on these loose teeth, discrete groupings were evident (Figure 60). A comparison of these groups was made to the Garnsey and Casper site populations and again it was found that the Norby site tooth wear was slightly behind that of the Garnsey site but more advanced than that of the Casper site.

However there are some minor differences in terms of M2 wear descriptions. For example, in the Garnsey Group 3 and 4, the endostyle of M2 is "lightly worn to a loop not joined to main occlusal surface, or unworn and just below the occlusal surface" (Wilson 1980: 103). At the Norby site, the M2 endostyle is not worn into a small circle until the 4.7 to 4.75 year old animals. This stage of wear coincides better with the Casper site's age group 6 (4.6 years) where the M2 endostyle is not yet in wear but is close to the main occlusal surface.

Overall, the age groups as determined by wear patterns on the maxillae tend to agree with the conclusions reached by the mandibular analysis in that the individuals appear to be N + 0.7 to 0.75 years old. The maxillary age groups at the Norby site are as follows:

<u>Group 1 to 2</u>: (0.7 - 1.75 years) No specimens available.

<u>Group 3</u>: (2.7 - 2.75 years) 2 specimens. Cusps on M3 not in wear; paracone height at 66 mm. No M2 specimen available. not in wear; strongly bilophodont.

<u>Group 4</u>: (3.7 - 3.75 years) 9 specimens. M3 endostyle average of 18 mm below main occlusal surface; anterior cusps exhibit minor wear while posterior cusps are either worn or just slightly polished; markedly bilophodont; roots widely

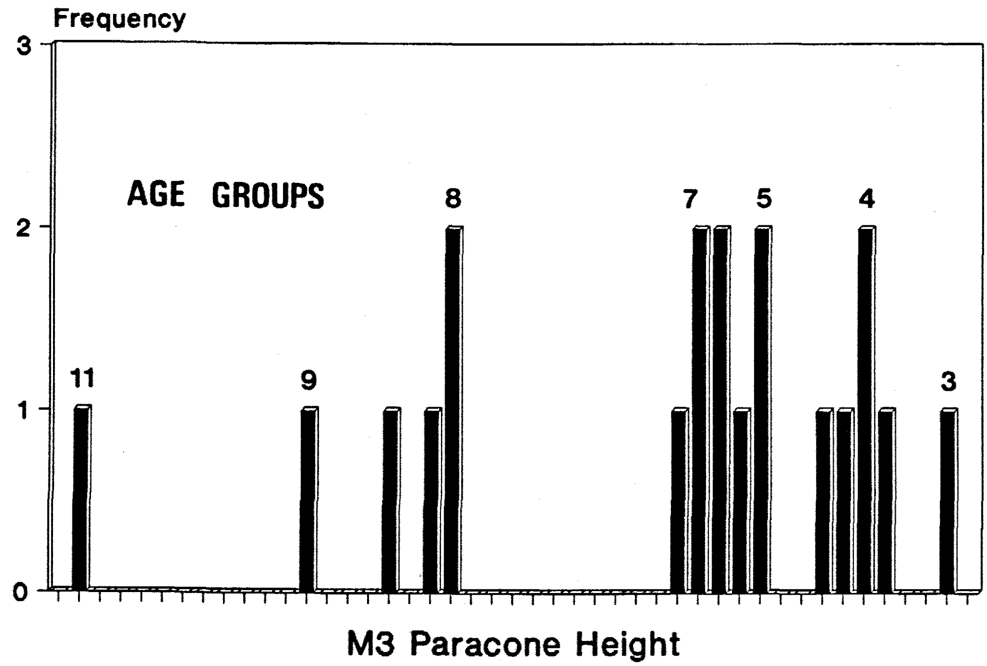


FIGURE 60 Measurement of paracone heights for determining age in seasonally restricted dental samples.

open and not fully formed. M2 endostyle not in wear, ranges from 3 to 1 mm below occlusal surface; strongly bilophodont; roots not fully formed. M1 endostyle worn into a circle distinct from main occlusal surface; moderately bilophodont.

<u>Group 5</u>: (4.7 - 4.75 years) 9 specimens. M3 endostyle still not in wear, 3 mm below main occlusal surface; root growth ranges from almost completely formed to fully developed and in place. M2 endostyle worn into a small circle distinct from main occlusal surface; moderately to strongly bilophodont. M1 endostyle forms a triangle to join with main occlusal surface; weakly bilophodont.

TABLE 20 Paracone heights of maxillary molars from the Norby site.

GROUP	AGE(yrs)	CATALOGUE NUMBER	SIDE	M1	M2	M3
3	2.7 - 2.75	2B-28	L	48	--	66
		18B-14	R	51	--	--
		X Group 3		50	--	66
4	3.7 - 3.75	13A-19	L	--	55	61
		20B-9	L	38	--	--
		20B-54	R	37	60	--
		2C-8	R	--	52*	60
		23B-12	L	--	57	63
		20B-55	L	--	57	62
		23B-54	L	35	--	--
		23B-13	R	--	--	62
		4C-25	L	30	54	--
		X Group 4		35	56	62
5	4.7 - 4.75	11B-47	R	29	49	55
		13A-21	R	--	53	--
		18B-15	L	34	48	--
		1B-2	R	32	49	57
		1B-38	L	--	--	57
		20B-10	L	32*	50	53*
		1B-1	L	32	49	--
		8A-25	R	28	48	53
		5B-10	L	--	46	--
		X Group 5		32	49	55
6	5.7 - 5.75	No specimens available				
7	6.7 - 6.75	6B-31	L	24	37	42
		4B-15	L	21	36	41
		21B-6	L	23	--	--
		4B-16	R	22*	35	42
		X Group 7		23	36	42
8	7.7 - 7.75	15A-21	R	--	30	39
		4C-21	R	19	32	--
		13A-21b	R	--	31	--
		X Group 8		19	31	39
9	8.7 - 8.75	10B-49	R	--	--	36
10	9.7 - 9.75	No specimens available				
11	10.7 - 10.75	21B-22	L	--	21	24

* estimated measurements

<u>Group 6</u>: (5.7 - 5.75 years) No specimens available.

<u>Group 7</u>: (6.7 - 6.75 years) 4 specimens. M3 endostyle ranges from unworn but just below the main occlusal surface to worn into a small circle distinct from occlusal surface; moderately bilophodont. M2 endostyle worn into a small triangle not yet joined to main occlusal surface; weakly bilophodont. M1 endostyle forms a loop to join with main occlusal surface; worn almost flat.

<u>Group 8</u>: (7.7 - 7.75 years) 3 specimens. M3 weakly bilophodont. M2 endostyle forms an elongated triangle that almost joins to the main occlusal surface; weakly bilophodont. No M1 specimen.

<u>Group 9</u>: (8.7 - 8.75 years) 1 specimen. M3 endostyle worn into an amorphous shape but still distinct from main occlusal surface. M2 endostyle forms a loop to join with main occlusal surface.

<u>Group 10</u>: (9.7 - 9.75 years) No specimens available.

<u>Group 11</u>: (10.7 - 10.75 years) 2 specimens. Specimens grouped mainly on paracone height. Individual 21B-22 has an M1 that is extremely worn, both the prefossetid and postfossetid are degenerated and the tooth cupped out.

Like the age group distribution based on the Norby site mandibles, that based on maxillae resembles a catastrophic rather than an attritional curve (Figure 61). Again the high number of "prime adult" individuals supports this conclusion. The reason for the absence of 5.7 year old animals is unknown but perhaps the small size of the sample combined with poor preservation of upper dentition is to blame.

The rate of attrition for the upper dentition coincides with that for the lower dentition (Table 21). The attrition rate for M1 over the eight year documented period is 5.5 mm; 5 mm for M2; and 5.3 for M3. As with the mandibles, upper molars confirm that the life expectancy for the Norby bison was in the range of eleven to twelve years.

6.5.3 Discussion

The Norby site upper and lower dentitions were subjected to an analysis similar to that conducted on the Garnsey site materials, based on metaconid and paracone height. Discrete age grouping were evident for both the lower and upper dentitions. These classifications became even clearer after wear patterns were studied and described.

After a detailed comparison with several other bison kill population studies, an estimated age of N + 0.7 to 0.75 years was suggested for the Norby site materials. If the annual

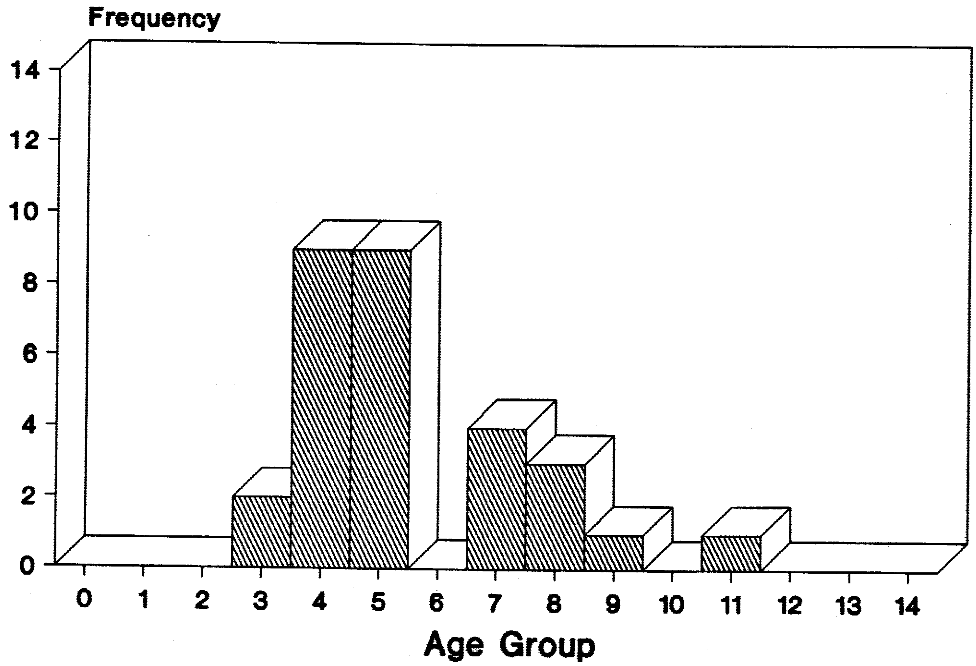


FIGURE 61 Age-group distribution of maxillae-based individuals at the Norby site.

TABLE 21 Age groups and paracone height measurements for the Norby site bison.

AGE GROUP	AGE IN YEARS	NUMBER OF MEASURABLE SPECIMENS	AVERAGE ENAMEL HEIGHT M1	M2	M3
1	0.7 - 0.75	-	--	--	--
2	1.7 - 1.75	-	--	--	--
3	2.7 - 2.75	2	50	--	66
4	3.7 - 3.75	9	35	56	62
5	4.7 - 4.75	9	32	49	55
6	5.7 - 5.75	0	--	--	--
7	6.7 - 6.75	4	23	36	42
8	7.7 - 7.75	3	19	31	39
9	8.7 - 8.75	1	--	--	36
10	9.7 - 9.75	0	--	--	--
11	10.7 - 10.75	1	--	21	24

calving pulse occurred between late April and late June (Frison 1976), this would place the Norby kill sometime during January or February. Winter kill sites are not uncommon on the Plains, especially in marginal regions (Wilson 1980: 120) like that described in Chapter 2 for the Norby site area. Kill sites, like Horner (Frison and Todd 1987), Agate Basin (Frison and Stanford 1982), Rex Rogers (Speer 1978) and Cherokee Sewer (Anderson and Semken, Jr. 1980) are all examples of Plains winter bison kills.

Age group distributions generated by the analysis of mandibles and maxillae enamel heights tend to agree with one another. Although they differ in sample size, the curves for both upper and lower dentition tend to resemble and partially complement one another. For instance, although the 3.7 - 3.75 (Group 4) and 4.7 - 4.75 (Group 5) year old individuals are better represented by maxillae, the 5.7 - 5.75 (Group 6) year old animals are well represented by mandibles. When the two curves are combined, using the largest available minimum number of individuals per age group, the resultant curve is obviously one characteristic of a catastrophic rather than an attritional death assemblage (Figure 62). The peaks at age groups 4 to 8 supports an hypothesis of cultural mortality because "even with accelerated molar attrition [this] seems to young for the onset of mortality through lowered condition in advanced age" (Wilson 1980: 114).

The absence of young individuals in kill site assemblages

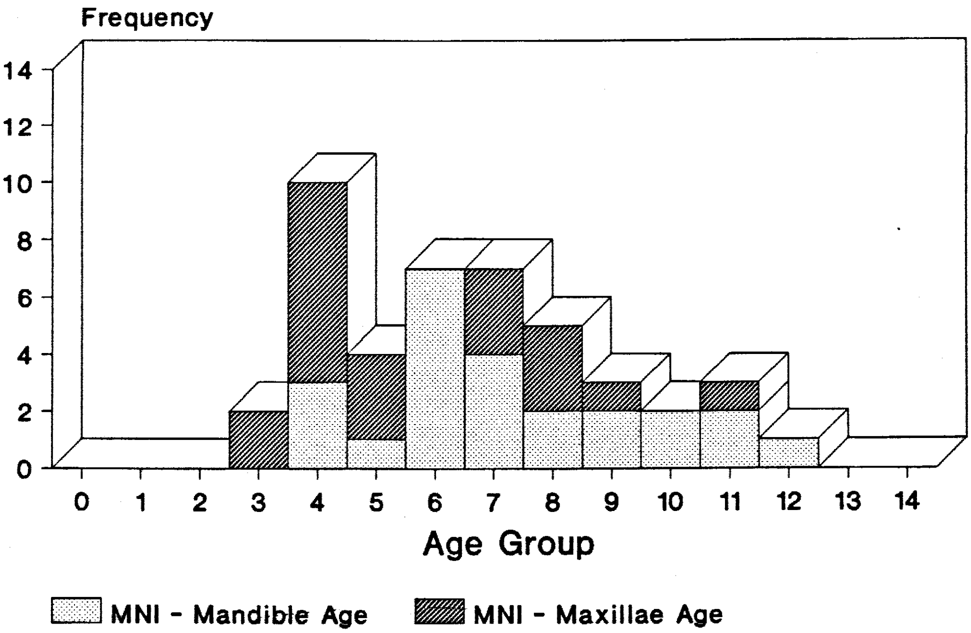


FIGURE 62 Age-group distribution of bison at the Norby site based on combined information from mandibles and maxillae (minimum number of individuals indicated on the vertical axis).

is not an uncommon occurrence. Many sites, like Glenrock (Frison 1970), Wardell (Reher 1973), Casper (Reher 1974; Wilson 1974), Itasca (Shay 1978) and Olsen-Chubbock (Wheat 1972), exhibit such a phenomenon. This circumstance is often associated with the differential removal of animals from the kill site by human groups (Frison 1982: 252; Reher 1974: 122; Wilson 1980: 115). Archaeologists speculate that the bodies of young, smaller animals were more readily butchered and quartered into portable units of meat. These units could then be easily transported back to a nearby campsite for further processing. However, at the Norby site the absence of young individuals can be explained in a different manner.

The sexing analysis, carried out on various bison elements from the Norby site, suggests that the assemblage is dominated by male individuals. This being the case, the absence of very immature animals is not very surprising because male bison herds usually consist of mature, or near mature, individuals only. The absence of animals in Age Group 1 and 2 and the severe lack of Age Group 3 individuals seems to generally support this hypothesis.

6.6 Bison Procurement

The Norby site is the result of the mass death of approximately 26 animals. Sexing analyses suggest that the majority of the animals represented are male individuals. The absence of young or very immature animals in the assemblage seems to support this to some extent.

A mass kill of a male herd is extremely rare in the archaeological record, because male animals are reported to be unpredictable and, as a result, difficult to manoeuvre in a drive situation (McHugh 1958; Frison 1974, 1976). However, situations do exist where site collections are dominated by males. At the Finley site, for example, males outnumbered females at a three to one ratio.

At the Norby site it is impossible to determine what type of kill actually took place. Because it is located within the bounds of a city environment, the present topography of the site is radically different from that of the past. However, since the site is located on an prehistoric river terrace, the Saskatoon Terrace, it is possible to assume that the topography was similar to the general character of the area presently surrounding the site. With the given situation, a jump or bog kill is unlikely. But, as a winter kill event (January or February), it is possible that a snow drift may have been employed or modified for use as a trap (Quigg 1978) at the Norby site. It is also possible that hunters may have intercepted a small group of bison as they were coming down to the open water of the river to drink. A similar scenerio is presented to explain the Finley site population because a small, male-dominated group of bison would be easy to handle in comparison to a large herd dominated by males (Frison 1976: 187).

CHAPTER SEVEN

SUMMARY AND CONCLUSIONS

The Norby site is an Early Middle Prehistoric bison kill situated on a relict terrace of the South Saskatchewan river within the city of Saskatoon, Saskatchewan. Radiocarbon dates for the site (S-3006, 5885 ± 265 BP; S-3205, 5740 ± 110 BP; S-3206, 5560 ± 120) cluster around 5700 BP, placing the site within a dry climatic interval known as the Altithermal. This prehistoric period is poorly known on the northern Plains.

Until recently, many researchers supported the idea of a "cultural hiatus" on the Plains during the Altithermal interval. An apparent lack of archaeological sites dating to this time period was thought to represent a climatically-induced abandonment of the region. In the last few years, however, a growing number of sites have been lending support to an opposing view. Rather than representing a cultural abandonment, it has been suggested that a lack of Altithermal sites was a direct result of their geological context. Reeves (1973) suggested that, because of their location, Altithermal sites were either deeply buried or eroded away and therefore, were not easily discovered. The location of the Norby site on a remnant terrace of the South Saskatchewan River, as well as the fact that it was found under one metre of overburden, seems to provide evidence in support of the preceding hypothesis.

It appears then, that the Plains were not completely abandoned during the dry Altithermal interval as was once thought. In fact, the episodic nature of Altithermal climate may have allowed for continous occupation of the Northern Plains. The Norby site, along with other sites like Gowen I and Gowen II (Walker 1980, 1987, 1988) in Saskatoon, provide evidence for human occupation during the height of the Altithermal, at least along major river courses like that of the South Saskatchewan River. And because the aforementioned sites are all located on the same landform, the Saskatoon Terrace, there is a potential for similar sites to be uncovered. The discovery of such sites would add further to our overall understanding of Plains occupation during this period.

The analysis of the lithic assemblage from the Norby site further strengthens the placement of the site within the Altithermal interval of the northern Plains. Although the sample was small, diagnostic tools were recovered. Of importance was the recovery of two complete side-notched projectile point which were identified as Gowen Side-notched projectiles. This point type is said to be characteristic of the time span from 6000 to 5100 BP (Walker 1980: 174). It appears then, that the Norby site radiocarbon dates are supported by these specimens.

Also of significance to the lithic analysis, and to the Norby site study in general, was the discovery of a stemmed projectile point during excavation of the site. This specimen was identified as a "Manitoba" point, a style described by Pettipas (1972) with data from a small number of Manitoba sites. Initially, on the basis of evidence from surface finds in Alberta and Manitoba, the "Manitoba" point style was thought to be associated with Hell Gap and Agate Basin-like point styles. Based on this apparent relationship to Paleoindian projectile points, the "Manitoba" point style was assigned an age of 8000 years. Pettipas (1980) also suggested that a relationship existed between the "Manitoba" point and what were considered similar specimens, known as Lovel Constricted projectile points (Frison 1978: 37), recovered from Medicine Lodge Creek, Wyoming. However, the <u>in situ</u> discovery of the "Manitoba" point at the Norby site places this style at a much later date than originally anticipated.

The Norby site evidence leads one to suggest that, at least in the Plains region of Canada, the "Manitoba" point type dates to the Early Middle Prehistoric period rather than the Paleoindian period. Pettipas'(1980) association of "Manitoba" projectile points with 8000 year old specimens from

Wyoming is also in question. Because the dates from the Wyoming locality and that now suggested by the Norby site evidence for the Canadian plains region are so drastically different, it is possible that two different projectile point types have been erroneously connected. However, further examination of point styles, their dates and <u>in situ</u> associations is required before definite conclusions can be reached.

Although the faunal assemblage at the Norby site was extremely weathered and highly fragmented, several preliminary conclusions could be reached regarding cultural activities that may have occurred at the site. A detailed analysis of element distribution and the frequency at which certain elements appeared in the assemblage, implied that only primary butchering occurred at the Norby site. The recovery of partially complete skeletons and articulated butchering units, coupled with the paucity of features such as hearths and boiling pits, indicated that meat was probably stripped from the bison carcasses and transported elsewhere for further processing. The fact that most elements were found whole before excavation also suggests that little attention was paid to marrow extraction or grease production at the kill site. Perhaps these, along with several other methods of intensive bone processing, were carried out at a nearby campsite.

It is not possible to comment more precisely on processing and butchering practices at the Norby site because severe weathering deteriorated bone surfaces to such an extent that cut mark analysis was impossible. However, the similarity of the faunal assemblage, in terms of element fragmentation and distribution, to several Paleoindian sites from the Plains region (Casper, Agate Basin and Horner sites) suggests that bison procurement and processing may have remained relatively unchanged from that of earlier periods. Evidence from the Norby site, in conjunction with data from the only other Altithermal component bison kill site in Canada, Head-Smashed-In, seems to support Reeves (1978) theory of a continuum of subsistence strategies on the Plains from the Early Prehistoric period throughout the Altithermal interval and into Late Prehistoric times.

The aging and sexing investigation of the Norby site faunal assemblage was extremely valuable as a means of offering some insight into Early Middle Prehistoric bison populations. Archaeologists generally agree that there was a Holocene dwarfing of bison and that the extinct forms of 11000 years ago, <u>Bison bison antiquus</u>, were much larger than the modern form, <u>Bison bison bison</u>, which were present on the Plains by about 5000 BP. It is also thought that the dwarfing process increased during the Altithermal in response to severe climatic conditions. Sexing analyses carried out on the Norby site faunal assemblage revealed that the specimens represented by the kill were those of a transitional species of bison, <u>Bison bison occidentalis</u> (or <u>Bison antiquus occidentalis</u>

[MacDonald 1981]). Long bone measurements from the Norby site were consistently found to be larger than those for modern bison yet somewhat smaller than the long bones of Bison bison antiquus forms. This phenomenon was also evidenced in the study of calcanei with the Norby site bivariate graphs exhibiting male/female clusters that were comparable to those of the Finley site's extinct bison.

With some certainty, then, it is suggested that the bison population at the Norby site consists of members of the extinct Bison bison occidentalis form. However, without horn cores, which are thought to be the most reliable indicator of species and sex, a definite conclusion cannot be reached. Future analysis of long bone and tarsals from the Hawken site and the Head-Smashed-In kill area may eventually lend support to the Norby site analyses and help to clarify the sequence of events that has led to the bison forms of today.

A second point of interest was raised by the sexing and aging analysis. Through the analysis of both upper and lower dentition it was possible to determine that the bison population represented by the Norby site faunal assemblage was catastrophic. In other words, the individual animals recovered at the site did not die from natural causes, but rather, were the result of a mass kill which froze the population as it existed and therefore contained viable adult animals (Frison 1974: 117).

The calving period for bison is seasonally restricted and therefore discrete age groups, all approximately one year apart, should be present at a catastrophic kill site. The Norby site population follows such a pattern. Age groups of N + 0.7 or 0.75 were determined with the youngest individuals at 3.7 to 3.75 years and the oldest animals at 11.7 to 11.75 years old. This places the kill event to sometime in the month of January or February.

At one time, almost all excavated kill sites on the Plains were found to have occurred in late fall or early winter. The reason for this seemed obvious; prehistoric people mass hunted bison in the fall as a means of stocking up meat for long winter months. In the last twenty years, however, several examples of winter kills have been discovered in the Plains region, including Agate Basin (Frison and Stanford 1982), Rex Rogers (Speer 1978), Jones-Miller (Standford 1978), Hawken (Frison et. al. 1976) and Cherokee Sewer (Anderson and Semken, Jr. 1980). It is now generally accepted that kills occurred throughout the entire year and were not restricted to one or two months in the fall.

Upon aging the Norby site dentition, it soon became apparent that there was an lack of very young animals at the site. Of the twenty-six animals represented, only two are thought to be slightly younger than four years of age. This type of population structure is not uncommon at kill sites because it is assumed that the younger animals, possessing the more desirable meat and hides, were often transported elsewhere for further processing. At the Norby site, however, sexing studies revealed that the herd was dominated by male animals. Therefore, the lack of young animals is not unusual because very young animals do not travel with male herds but stay with the female animals until they reach maturity.

The representation of a small male herd at a mass kill is extremely uncommon. Not only are mature males thought to be disruptive to systematic bison driving (Frison et. al 1976), but it is usually assumed that large numbers of animals are required for driving purposes. There are, however, other examples, besides the Norby site, of sites which possess relatively small herds dominated by males. At the Finley site, analysis of calcanei revealed a population of 75% males and 25% females (Hapsel and Frison 1987) and at the Hawken site, at least one winter kill event was that of a mature male herd.

The strategy or strategies involved in the procurement of bison at the Norby site may never be completely understood. Because of the constraints of the urban environment, there were no means by which the necessary geomorphological information could be gathered. It is possible, however, to offer some hypotheses. Because the Norby site represents a winter kill, it is possible that a snow drift was utilized or modified to act as a trap. Given the climate of the time, with episodic periods of drier, warmer conditions, it is more probable that a small group of animals were taken as they came to the open water of the river to drink. A similar scenario was suggested for the Finley site (Hapsel and Frison 1987) because, if it is a male herd that is being hunted, a small group is easier to manipulate. The location of the Norby site on a relict terrace of the South Saskatchewan River, the size of the herd represented (MNI = 26) and the fact that it is a herd dominated by males seems to provide some support for the above hypothesis. Without solid geomorphological evidence to support it though, the above hypothesis remains extremely conjectural.

The significance of the Norby site is undeniable. Mummy Cave vintage sites are uncommon on the northern Plains, the Norby site representing the third such find in Saskatchewan. As a result, some of the information presented here is the first of its kind and has hopefully helped contribute to our overall understanding of the Early Middle Prehistoric Period in Plains prehistory along the South Saskatchewan River.

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APPENDIX ONE

Canid Mandible Measurements

MEASUREMENTS

All measurements taken on the two canid mandibles recovered from the Norby site are those of Von Den Driesch (1976: 61 -62). They are as follows:

1) Total length from condyle to anterior portion of mandibular symphysis

2) Length from angular process to anterior aspect of mandibular symphysis

3) Length from indentation between condyle process and angular process to anterior of the mandibular symphysis.

4) Length from condyle process to aboral border of the canine alveolus

5) Length from the indentation between the condyle process and the angular process to the aboral border of the canine alveolus.

6) Length from the angular process to the aboral border of the canine alveolus.

7) Length of the aboral border of the alveolus of M3 to the aboral border of the canine alveolus.

8) Length of the cheektooth row, M3 - P1, measured along the alveoli.

9) Length of the cheektooth row, M3 - P2, measured along the alveoli.

10) Length of the molar row, measured along the alveoli.

11) Length of the premolar row, P1 - P4, measured along the alveoli.

12) Length of the premolar row, P2 - P4, measured along the alveoli.

13) Length and breadth of carnassial, measured at the cingulum (Fig. A1.1b).

14) Length of the carnassial alveolus.

15) Length and breadth of M2, measured at the cingulum.

16) Length and breadth of M1, measured at the cingulum (Figure A1.1d).

17) Greatest thickness of the body of the jaw (below M1).

18) Height of the vertical ramus: basal point of the angular process to the coronion.

19) Height of the mandible behind M1, measured on the lingual side and at right angles to the basal border.

20) Height of the mandible between P2 and P3, measured on the lingual side and at right angles to basal border.

21) Height (length) of the canine, measured in a straight line form point to point. This measurement is only possible is the tooth can be removed from the jaw. Not shown in Figure A1.1a.

22) Calculation of the basal length (following Brinkman 1924): measurement no. 2 multiplied by 1.21.

23) Calculation of the basal length (following Brinkman 1924): measurement no. 4 multiplied by 1.37.

24) Calculation of the basal length (following Brinkman 1924): measurement no. 5 multiplied by 1.46.

25) The mean of measurements 22, 23 and 24.

TABLE A1.1 Canid mandible measurements for the Norby site.

MEASUREMENT	L	R	MEASUREMENT	R	L
1	169.5	168.6	14	27.1	29.0
2	168.7	167.8	15	---	11.0/9.0
3	163.3	159.0	16	---	---
4	148.0	---	17	15.0	15.5
5	143.0	---	18	70.8	72.1
6	148.3	---	19	31.7	30.1
7	101.0*	---	20	26.9	23.0
8	96.0*	---	21	---	---
9	91.0*	---	22	204.1	203.0
10	49.3	51.0*	23	202.8	---
11	49.0	---	24	208.8	---
12	43.0	---	25	205.2	---
13	28.7/11.8	28.5/11.8	26	234.4	---

* estimates

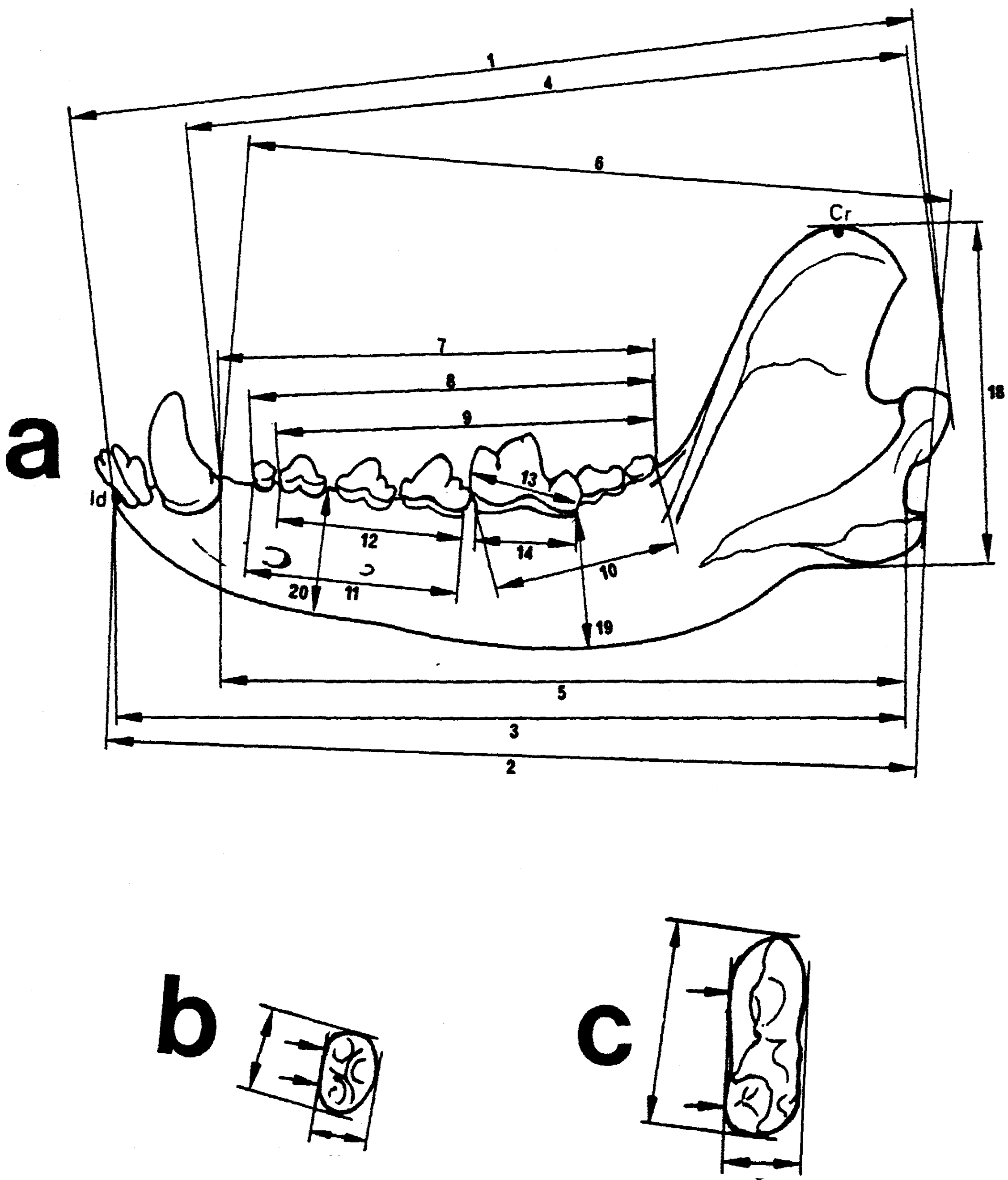


FIGURE A1.1 Measurements of canid mandibles and teeth. Buccal (a) view of the jaw, M2 (b) and M1 (c) teeth (From Von den Dreisch 1976).

APPENDIX TWO

Bison Element Measurements and Bivariate Graphs

A. BISON ELEMENTS MEASUREMENTS

Measurements utilized in the analysis of the Norby site bone were derived from a number of sources including Lorrain (1968), Duffield (1973), Roberts (1982), Speth (1983), Todd (1987), Morlan (1989) and Bedord (1974). All measurements presented below were used previously by the above mentioned authors. Equivalent measurement (Table A2.1) are provided only for the long bones because more than one source was used.

During each analysis, every measurement, except astragali volumes, were taken twice to ensure replicability. If the first two were not with 0.5 mm of each other a third measurement was taken. The mean for all three was recorded as the right measurement.

Table A2.1 Equivalent measurements, by other authors, to those presented for the Norby site bone analysis.

Norby Site Code	Speth (1983)	Todd (1987)	Norby Site Code	Speth (1983)	Todd (1987)
HUMERUS:					
H1	I	HM7			
H2	J	-	RADIUS:		
H3	K	-	R1	A	RD3
H4	M	-	R2	B	-
H5	N	-	R3	C	RD10
H6	O	-	R4	D	-
H7	-	HM11	R5	E	-
H8	-	HM14	R6	-	RD4
			R7	-	RD9
TIBIA:			R8	G	RD7
T1	H	TA10	R9	I	-
T2	I	TA14	R10	J	-
T3	J	-	R11	K	-
T4	K	-	R12	-	RD11
T5	L	-			

Metapodials

The following list of measurements for both metacarpals and metatarsals are taken from Bedord (1974: 201-203). They have, however, been coded differently using a method similar to what Todd (1987) incorporates into the Horner site study. Measurement codes for the Norby site will be given first and the equivalent measurement code, as described by Bedord (1974), will follow in parentheses.

M1 (No. 1) Length: Maximum length is measured by placing the bone posterior side down on an osteometric board with the distal condyles lying flat on the board and the midline paralleling the centre slide. The measurement in taken from the highest point on the proximal end (Figure A2.1).

M2 (No. 2) Transverse width at proximal end: Transverse taken with callipers. The base of measurement is the line across the bone which touches the posterolateral muscle attachment and whichever of the two posteromedial muscle attachments protrudes further. Transverse width is taken with the further. Transverse width is taken with the calliper slides at right angles to this line (Figure A2.2a).

M3 (No. 3) Transverse width at centre of shaft: The measurement is taken with callipers with the bone lying on a flat surface. The distal end is placed flat. The centre of the bone was usually judged visually, but frequent checks were made by measuring the distance between the two ends and checking the midpoint (Figure A2.1).

M4 (No. 4) Transverse width of distal end: Using the osteometric board, the cannon bone is placed with the distal end flat and the midline perpendicular to the centre slide (Figure A2.1). The greatest width measured in this manner is the correct measurement.

M5 (No. 5) Anterior-posterior width at centre of shaft: This is measured in the same manner as M3 with one edge of callipers flat against the posterior side (Fig. A2.2b).

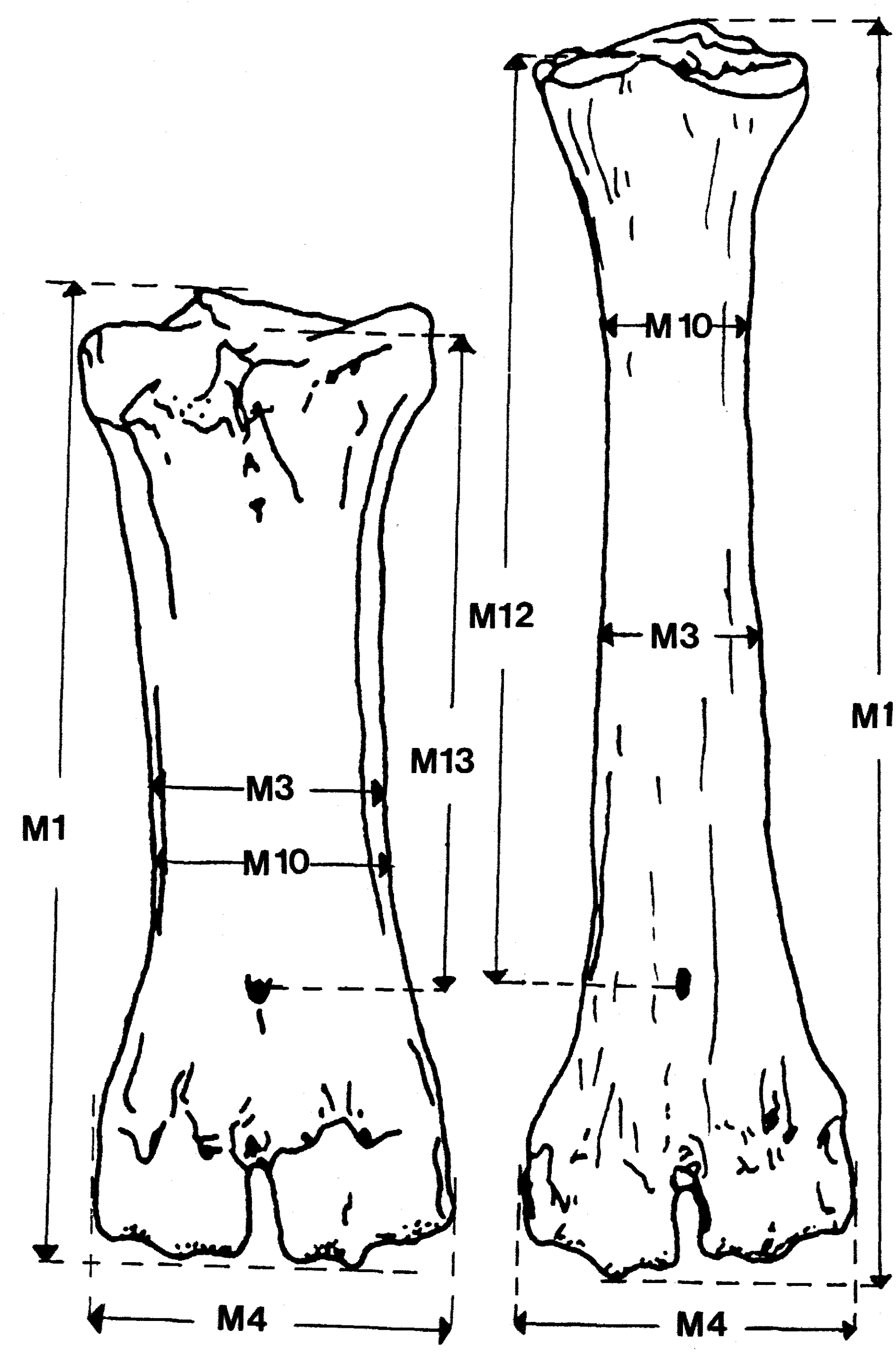


FIGURE A2.1 Anterior view of right metapodials (From Bedord 1974).

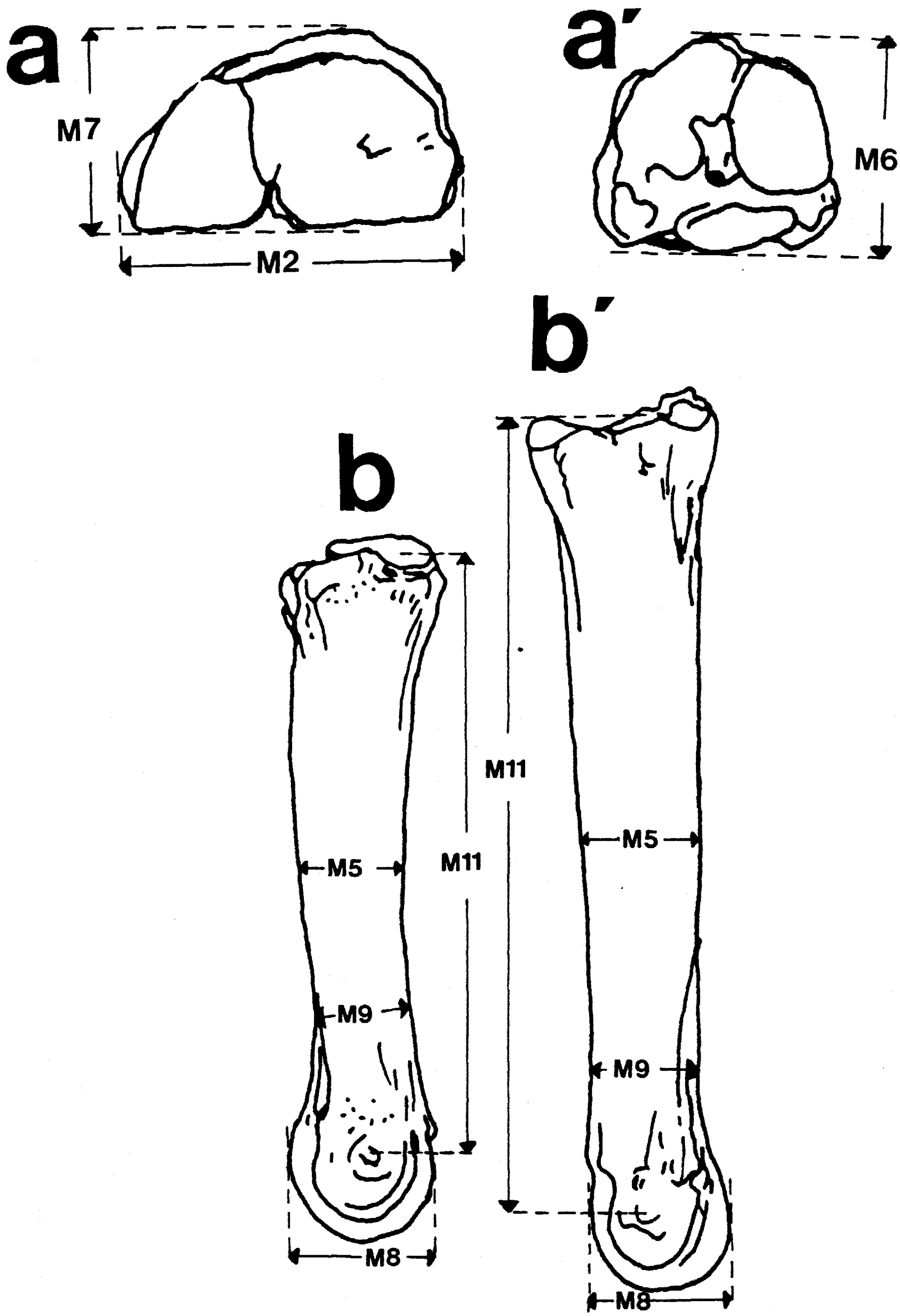


FIGURE A2.2 Proximal (a,a') and medial (b,b') views of right metapodials (From Bedord 1974).

M6 and M7 (No. 6 and No. 7) Anterior-posterior width of proximal end: On the posterior side, the proximal end of a metapodial has three distinct tuberosities (Figure A2.2a). Measurements were taken from both the medial and centre tuberosities. Due to problems with replicability, measurement M6 for metacarpals is omitted from the final analysis; for metatarsals, M7 is omitted.

M8 (No. 8) Anterior-posterior width of distal end: This measurement is taken by placing the specimen in the osteometric board so the length is perpendicular to the centre slide and either the lateral or medial side faces up. The measurement is the greatest width of either the condyles or the epiphysis (Figure A2.2b).

M9 (No. 9) Minimum anterior-posterior width of the shaft: This is measured at variable points along the shaft. The narrowest point may be determined visually or by sliding the closed callipers until they cannot be moved in either direction without increasing the width (Figure A2.2b).

M10 (No. 10) Minimum lateral width of shaft: This measurement is taken in the same manner as M9 with the callipers rotated 90 degrees then moved to the narrowest point (Figure A2.1).

M11 (No. 11) Rotational length: The distance from the centre of rotation, medial side, to the proximal articular surface is measured by placing one point of the callipers in the indentation on the condyle, then the other point on the articular surface (Figure A2.2b). The shortest distance, i.e., the lowest point on the articular surface, is the correct reading.

M12 (No. 12) Foramen to articular surface length, anterior side: This is measured from the midline foramen on the distal end, anterior side, to the highest point on the articular surface (Figure A2.1). This does not necessarily parallel the midline.

M13 (No. 13) Foramen to articular surface length, posterior side: This is measured the same as M12, except from the posterior side and to the lowest point on the articular surface (Figure A2.1).

TABLE A2.2 Norby Site Metatarsal Data (Measurements are all in mm).

SPECIMEN NUMBER	SIDE	M1	M2	M3	M4	M5	M6	M8	M9	M10	M11	M12	M13	R1	R2	R3	R4	R5	R6
15A-37	L	284.5	71.0	39.9	77.0	41.0	63.0	44.5	34.0	38.0	236.5	209.5	210.0	1.21	1.1	1.20	1.36	1.35	14.02
6D-11	L	--	--	--	77.5	--	--	41.5	--	--	--	--	--	--	--	--	--	--	--
6A-44	L	279.0	60.0	38.7	72.5	38.0	57.0	43.0	33.0	37.0	235.0	200.0	207.0	1.15	1.0	1.19	1.40	1.35	13.87
16B-51	R	273.5	62.0	39.0	76.5	37.5	60.5	42.0	32.0	37.0	229.0	208.5	208.0	1.17	1.1	1.19	1.31	1.31	14.26
7A-20	R	275.5*	66.0	41.6	75.0	39.0	60.0	42.0	33.0	40.0	228.0	201.0	205.0	1.18	1.0	1.20	1.36	1.33	15.24
1C-48	R	275.0	63.5	40.5	73.5	36.5	59.5	43.5	31.5	--	235.0	198.5	202.0	1.16	--	1.17	1.39	1.36	14.73
2C-11	L	273.0	62.0	39.0	72.0	40.0	57.5	42.0	34.0	--	233.0	204.5	204.5	1.18	--	1.17	1.33	1.33	14.29
7B-37	R	273.5	58.0	32.0	70.5	31.5	54.5	42.0	31.5	31.0	234.0	207.0	204.0	1.00	1.0	1.17	1.32	1.34	11.70
11A-73	L	272.0	56.0	34.0	70.5	33.0	55.0	41.0	31.0	33.0	228.5	203.0	200.5	1.06	1.0	1.19	1.34	1.36	12.50
5A-4	L	271.0	60.0	36.0	70.0	35.0	56.6	42.5	32.0	--	230.0	197.0	200.0	1.09	--	1.17	1.37	1.35	13.33
7A-41	L	271.0	65.5	41.0	74.5	37.0	59.5	43.0	32.0	--	227.0	200.5	--	1.16	--	1.19	1.35	--	15.13
16B-78	L	269.5	61.0	40.5*	73.6	--	59.0	42.0	31.5	--	230.0	200.5	201.5	--	--	1.17	1.34	1.34	15.03
1D-10	L	--	61.0	--	72.0	--	60.0	43.0	--	--	--	--	--	--	--	--	--	--	--
13A-45	R	262.0	64.0	40.0	72.0	37.5	60.0	43.0	33.5	--	217.5	197.0	200.0	1.12	--	1.20	1.33	1.31	15.27
16B-91	R	268.0	63.0	35.5	72.0	35.0	60.0	41.0	32.0	--	229.0	199.5	203.0	1.09	--	1.17	1.34	1.32	13.25
6A-38	L	253.0	59.5	38.0	68.5	37.0	56.5	39.5	31.0	36.0	212.5	186.5	188.5	1.19	1.1	1.19	1.36	1.34	15.02
9A-8	R	250.0	58.5	37.7	68.5	33.5	55.0	39.0	31.0	36.0	215.5	185.0	187.5	1.08	1.0	1.16	1.35	1.33	15.08
16B-52	-	--	--	--	75.0	--	--	42.0	31.5	--	--	--	--						
12B-36	R	--	--	--	73.0	--	--	40.5	32.0	--	--	--	--						
4C-45	-	--	--	--	69.0	--	--	40.0	--	--	--	--	--						
4C-53	R	--	--	--	72.0	--	--	38.5	30.0	--	--	--	--						
6B-21	L	--	--	--	71.5	--	--	40.0	32.5	--	--	--	--						
9B-48	L	--	--	--	70.0	--	--	42.5	32.0	--	--	--	--						
17B-10	-	--	--	--	62.5	--	--	38.0	30.0	--	--	--	--						
7A-2	L	--	--	--	72.0	--	--	40.0	31.5	--	--	--	--						
14A-42	L	--	--	--	69.0	--	--	43.0	--	--	--	--	--						
12A-32	L	--	59.5	--	67.0	--	57.0	39.5	--	--	--	--	--						
4C-18	R	--	58.5	--	72.0	--	57.0	40.0	--	--	--	--	--						
10B-32	R	--	--	--	73.0	--	--	42.5	33.0	--	--	--	--						
7B-14	-	--	--	--	--	--	--	41.0	31.0	--	--	--	--						
MINIMUM		250.0	51.5	32.0	62.5	31.5	50.5	38.0	30.0	31.0	212.5	185.0	187.5	1.00	1.0	1.16	1.31	1.31	11.70
MAXIMUM		284.5	71.0	41.6	77.5	41.0	63.0	44.5	34.0	40.0	236.5	209.5	210.0	1.21	1.1	1.20	1.40	1.36	15.27
MEAN		269.8	61.1	38.2	1.8	36.5	57.8	41.4	32.0	36.0	228.0	199.9	201.5	1.13	1.0	1.18	1.35	1.34	14.18
STANDARD DEVIANCE		8.6	4.0	2.7	3.1	2.6	2.8	1.6	1.1	2.6	7.1	6.7	6.2	0.06	0.0	0.01	0.02	0.02	1.05
VARIANCE		74.7	16.3	7.1	9.5	6.7	7.7	2.6	1.1	7.0	49.9	44.6	39.0	0.00	0.0	0.00	0.00	0.00	1.10

*esitmates

TABLE A2.3 Norby Site Metacarpal Data (Measurements are all in mm).

SPECIMEN NUMBER	SIDE	M1	M2	M3	M4	M5	M7	M8	M9	M10	M11	M12	M13	R1	R2	R3	R4	R5	R6
11A-23	R	199.0	73.5	45.0	77.0	--	43.0	41.0	--	--	169.5	150.0	141.0	--	--	1.17	1.32	1.41	22.61
9A-29	L	220.0	74.5	48.0	81.0	--	--	43.0	--	--	185.0	166.5	--	--	--	1.19	1.33	--	21.28
16B-35	R	217.0	78.0	46.0	81.0	--	46.0	42.5	--	--	184.0	164.0	158.0	--	--	1.18	1.32	1.37	21.02
8A-49	R	212.0	80.0	52.0	80.0	33.5	47.0	43.0	30.0	51.5	179.0	161.5	153.0	1.12	1.0	1.18	1.31	1.39	24.53
10B-90	R	211.0	75.5	46.0	76.0	31.5	48.0	41.0	28.5	45.0	180.0	156.0	148.5	1.11	1.0	1.17	1.35	1.42	21.80
10B-17	L	213.0	81.0	50.0	84.0	32.0	44.5	44.0	28.0	50.0	182.0	161.0	152.5	1.14	1.0	1.17	1.32	1.40	23.47
11A-19	L	222.0	77.0	45.0	81.0	28.0	46.0	44.0	28.0	--	187.0	168.0	159.5	1.00	--	1.19	1.32	1.39	20.27
1A-8	R	222.0	--	--	80.0	--	44.5	39.0	--	--	187.0	170.0	160.5	--	--	1.19	1.31	1.38	--
2D-32	L	214.0	78.5	48.5	79.0	--	44.0	40.0	--	--	184.5	160.0	154.0	--	--	1.16	1.34	1.39	22.66
15A-1	L	218.0	68.0	--	69.0	--	42.0	36.0	26.0	--	186.0	166.5	159.0	--	--	1.17	1.31	1.37	--
13A-72	L	199.0	76.6	46.0	77.0	31.5	45.5	39.5	27.5	45.4	168.0	151.0	141.5	1.15	1.0	1.18	1.32	1.41	23.12
10B-21	L	211.0	74.5	47.0	77.0	31.0	48.0	39.0	29.0	46.0	178.0	155.5	148.0	1.07	1.0	1.19	1.36	1.43	22.27
6D-25	R	215.0	80.5	53.9	82.5	31.0	46.0	42.0	31.0	53.0	183.0	159.0	154.5	1.00	1.0	1.20	1.35	1.39	25.10
10B-26	R	214.0	81.0	48.0	82.0	32.5	44.0	45.0	28.0	48.0	179.0	160.0	150.0	1.16	1.0	1.18	1.34	1.43	22.43
4An-29	R	220.0	76.0	45.0	79.5	30.0	45.0	39.0	--	45.0	187.0	169.5	163.5	1.03	1.0	1.19	1.30	1.35	20.45
2A-29	L	213.0	--	47.0	80.0	--	--	40.0	--	--	178.5	162.0	157.0	--	--	1.18	1.31	1.36	22.07
19B-41	R	220.0	82.0	47.0	82.0	32.5	48.5	43.5	--	--	186.5	167.0	158.0	1.16	--	1.19	1.32	1.39	21.36
2D-1	R	209.0	--	45.5	81.0	--	--	41.0	--	--	176.0	155.0	--	--	--	1.20	1.35	--	21.77
6A-29	-	--	75.0	--	--	--	44.5	--	--	--	--	--	--						
21B-46	-	--	69.5	--	--	--	40.5	--	--	--	--	--	--						
25B-23	-	--	72.5	--	--	--	40.5	35.0	--	--	--	--	--						
15B-50	-	--	78.0	--	81.5	--	46.0	42.0	--	--	--	--	--						
8B-25	-	--	79.0	--	83.0	--	48.0	42.5	--	--	--	--	--						
2C-2	-	--	--	--	80.0	--	--	40.0	--	--	--	--	--						
6D-19	-	--	--	--	78.0	--	--	37.5	--	--	--	--	--						
15A-40	-	--	--	--	87.0	--	--	45.0	--	--	--	--	--						
25B-29	-	--	--	--	70.0	--	--	38.0	--	--	--	--	--						
9B-34	-	--	--	--	83.5	--	--	41.5	--	--	--	--	--						
MINIMUM		199.0	68.0	45.0	69.0	28.0	42.0	36.0	26.0	45.0	168.0	150.0	141.0	1.03	1.0	1.16	1.30	1.35	20.27
MAXIMUM		222.0	82.0	53.9	87.0	33.5	48.5	45.0	31.0	53.0	187.0	170.0	163.5	1.16	1.0	1.20	1.36	1.43	25.07
MEAN		213.8	76.8	47.5	79.7	31.4	45.1	40.9	28.5	48.0	181.1	161.3	153.7	0.99	1.0	1.18	1.33	1.39	19.83
STANDARD DEVIANCE		6.5	3.6	2.5	3.3	1.5	1.8	2.3	1.3	3.0	5.6	5.9	6.3	0.32	0.0	0.01	0.02	0.02	7.11
VARIANCE		42.3	11.6	6.2	14.9	2.1	5.2	6.6	1.6	8.7	30.9	34.8	39.9	0.10	0.0	0.00	0.00	0.00	50.55

* estimated measurements

Humerus

Only distal humeri were in a state of preservation that allowed for an analysis to be carried out. A total of nineteen (MNI = 12) specimens were included in the study, two of which were immature. A sliding calliper was used for all of the following measurements. Measurements were taken from Speth (1983) and Todd (1987) but have been given a Norby site code designation.

H1 Greatest breadth of distal condyle (Speth 1983): Measured parallel to longitudinal axis of condyle on anterior surface (Figure A2.3a).

H2 Length of trochlea (Speth 1983): Measurement taken from bottom of shallow depression immediately caudal to proximal edge of articular surface of trochlea to bottom of shallow depression immediately caudal to distal edge of articular surface (Figure A2.3b).

H3 Greatest diagonal depth of medial epicondyle (Speth 1983): This is taken from the bottom of the shallow depression immediately caudal of the medial epicondyle to the distal edge of the articular surface (Figure A2.3b).

H4 Breadth of distal condyle (Speth 1983): Taken at proximal edge of articular surface (Figure A2.3a).

H5 Length of capitulum (Speth 1983): Measured perpendicular to distal edge of lateral epicondyle (Fig. A2.3c).

H6 Length of lateral epicondyle (Speth 1983): Measurement is taken from (and perpendicular to) the distal edge of the lateral epicondyle to the proximal eminence of the lateral epicondyloid crest (Figure A2.3c).

H7 Greatest medial depth of distal end (Todd 1987): The humerus is held in a vertical position, with the major (lateral) tuberosity resting on the table. The medial surface towards you. The fixed jaw of the callipers is set on the caudal margin of the medial epicondyle. The moveable jaw is placed on the cranial extreme of the trochlea. The rack of the callipers rests on the lateral surface of the medial epicondyle (A2.3d).

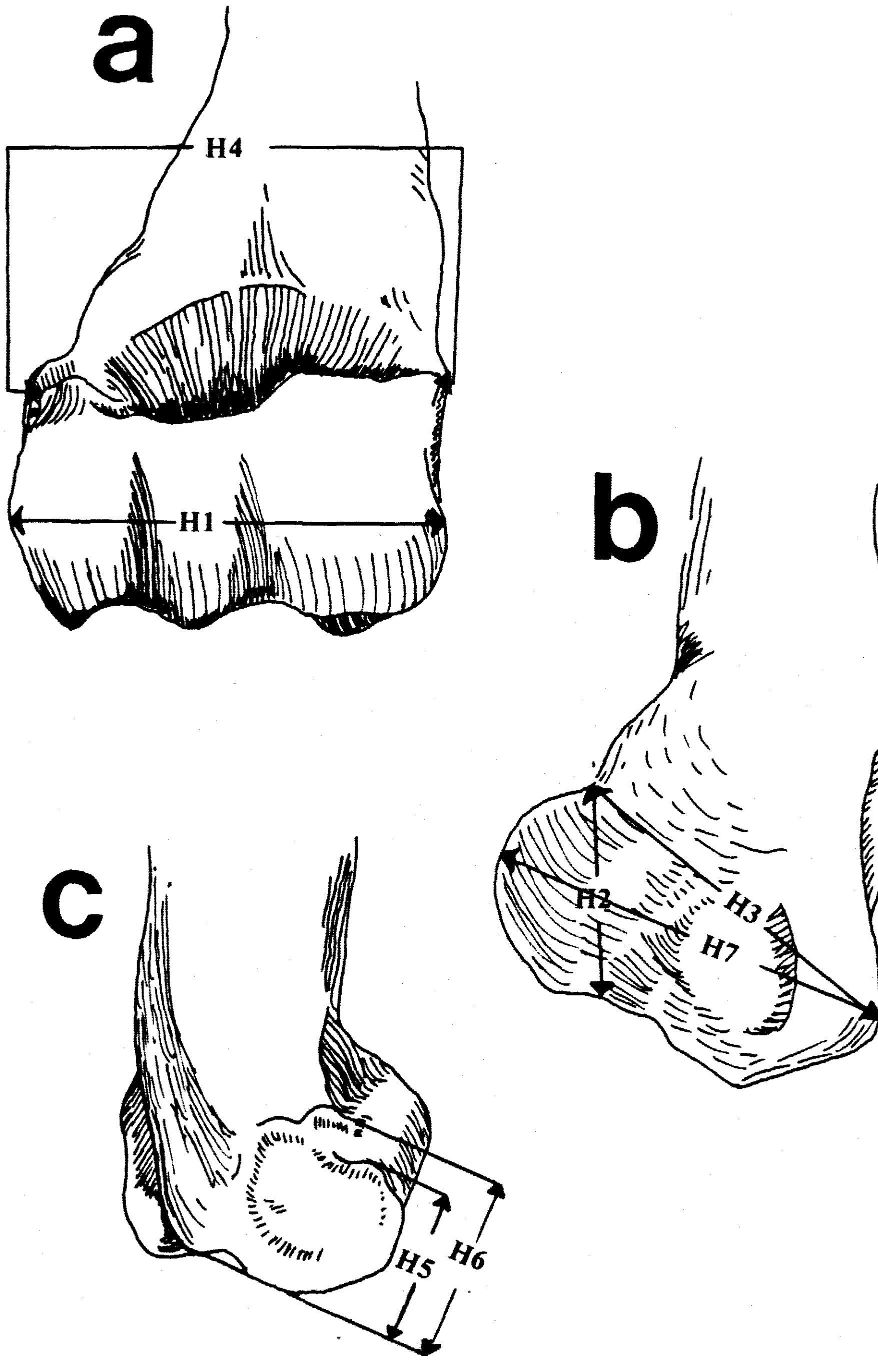


FIGURE A2.3 Right distal humerus. Cranial (a), medial (b) and lateral (c) views (From Speth 1983).

H8 Least medial depth of distal end (Todd 1987): The humerus is held vertically with the medial surface towards you. One jaw of the callipers is placed on the caudal-most portion of the central groove of the distal articular surface. The other jaw is positioned on the cranial-most aspect of the groove.

TABLE A2.4 Norby site mature humeri data (All measurements are in mm).

SPECIMEN NUMBER		H1	H2	H3	H4	H5	H6	H7	H8
3A-33	R	92*	--	--	90	45	52	--	45
4A-17	L	100	--	--	99	42	--	--	--
12A-34	L	91	54	93	89	44	53	104	45
14A-54	R	--	57	88	--	42	52	100	44
15A-36	R	99	70	--	92	--	--	--	--
15A-67	R	97	61	103	91	43	54	106	46
4B-60	L	88	63	--	83	38	45	--	43
4B-67	R	99	57	97	88*	--	--	110	47
5B-1	L	92	64	--	91	44	55	--	48
8B-43	L	97	--	--	88	45	53	--	48
10B-14	L	98	60	--	85	43	53	--	46
10B-47	L	100	70*	--	86	45	55	103	49
14B-4	R	97	62	97	92	43	54	107	46
14B-24	L	99	62	101	92	--	--	109	49
19B-32	R	--	--	--	91	47	53	--	47
23B-7	R	89	54	--	82	41	46	--	44
MINIMUM		88	54	88	83	38	45	100	43
MAXIMUM		100	70	103	99	47	54	110	49
MEAN		96	62	96	89	43	52	105	46

*estimates

TABLE A2.5 Norby site immature humeri data (All measurements are in mm).

SPECIMEN NUMBER		H1	H2	H3	H4	H5	H6	H7	H8
16B-6	L	91	59	93	86	42	51	102	46
3C-21	L	93*	65*	92	88	44	51	102	49
MEAN		92	62	93	87	43	51	102	48

* estimates

Radius

Measurements were made on both proximal (N =15; MNI = 9) and distal radii (N = 14; MNI = 9). These numbers included five immature specimens for both proximal and distal portions of the radius. An osteometric board and a sliding callipers were used in this analysis.

R1 Greatest breadth of proximal end (Todd 1987): This measurement is taken with the osteometric board. Cranial surface of the radius rests on the osteometric board and the rest of the bone extends vertically. The greatest measurement is the correct one (Figure A2.4a).

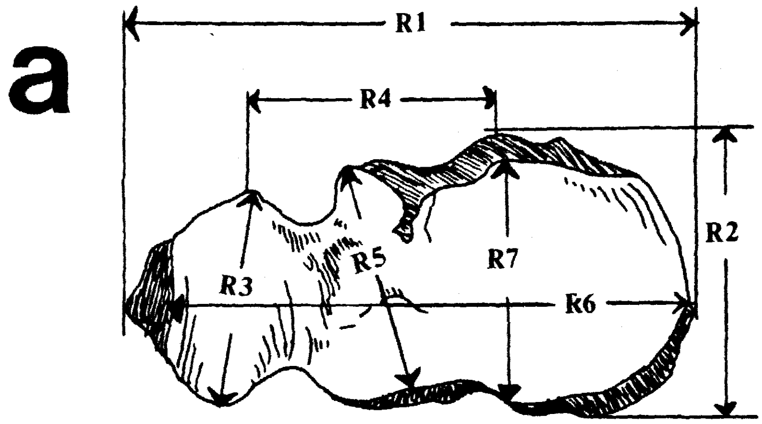
R2 Greatest depth of proximal end (Speth 1983): This measurement is taken in the same manner as R1 but the bone is rotated so that the cranial surface is perpendicular to the centre slide (Figure A2.4a).

R3 Greatest depth of capitular articular surface (Speth 1983): Use a callipers. Measured from the caudal edge of the capitular articular surface at the eminence formed by lateral edge of lateral ulnar facet (Figure A2.4a).

R4 Breadth between lateral and medial ulnar facets (Speth 1983): Measured on caudal edge of capitular and trochlear articular surfaces between the eminences formed by lateral edge of lateral ulnar facet (same as in R3) and medial edge of medial ulnar facet (Figure A2.4a).

R5 Depth of sagittal ridge (Speth 1983): Measured from eminence at medial edge of lateral ulnar facet on caudal edge of proximal articular surface (Figure A2.4a).

R6 Greatest breadth of proximal articular surface (Todd 1987): The radius is held in a vertical position with the caudal surface towards you. One jaw of the callipers is fixed against the flat, lateral margin of the humeral articular surface. The rack of the callipers rests on the cranial extreme of the capitular fovea. The other jaw of the callipers contacts the medial extreme of the capitular fovea (Figure A2.4a).



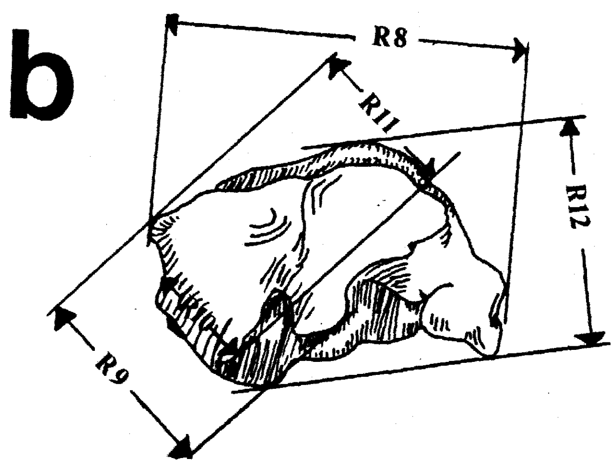


FIGURE A2.4 Right proximal (a) and left distal (b) views of the radius (From Speth 1983).

R7 Greatest depth of proximal articular surface (Todd 1987): The radius is held veritcally with the cranial surface towards you and the proximal end up. One jaw of the callipers is fixed against the caudal surface of the capitular fovea and the other jaw contacts the cranial portion of the humeral articular surface. The callipers are rotated until a maximum reading is reached (Figure A2.4a).

R8 Greatest breadth of distal end (Speth 1983): Measurement is taken between points of lateral and medial epiphyseal fusion using a callipers. The greatest measurement is the correct one (Figure A2.4b).

R9 Greatest breadth of internal and radial carpal articular surfaces (Speth 1983): This is measured diagonally from the lateral edge of the internal carpal facet to the prominent tuberosity for attachment of the medial collateral ligament of carpal joint (Figure A2.4b).

R10 Minimum breadth of radial carpal facet (Speth 1983): This measurement is made parallel to R9 at the caudal edge of the facet (Figure A2.4b).

R11 Greatest breadth of radial carpal facet (Speth 1983): Measured parallel to R9 and R10 from lateral edge of facet (same as in R10) to prominent tuberosity for attachment of medial collateral ligament of carpal joint (same as in R9) (Figure A2.4b).

R12 Greatest depth of distal end (Todd 1987): The distal radius is placed on the osteometric board in a transverse orientation, with the caudal surface fixed against the end of the board and the medial surface resting on the base of the board. The slider contacts the cranial extreme of the distal end (Figure A2.4b).

TABLE A2.6 Norby site mature proximal radii data (All measurements in mm).

SPECIMEN NUMBER		R1	R2	R3	R4	R5	R6	R7
13A-31	L	96	51	31	58	40	93	50
2B-24	R	100	54	31	55	41	92	54
2B-70	R	108	55*	32	61	38	98	--
3B-16	R	98	50	33	53	--	93	49
10B-41	L	107	60	32	62	40	100	54
15B-28	R	107	54	34*	--	--	98	53*
3C-15	L	95	52	32	54	43	88	52
6D-29	R	100	53	33	57	31	96	51
MINIMUM		95	51	31	53	31	88	49
MAXIMUM		108	60	34	62	43	100	54
MEAN		101	54	32	57	39	95	51

* estimates

TABLE A2.7 Norby site immature proximal radii data (Measurements in mm).

SPECIMEN NUMBER		R1	R2	R3	R4	R5	R6	R7
1A-10	R	102	47	32	57	40	93	47*
2.2A-14	L	--	51	--	--	--	--	49
4B-14	L	97	51	31	62	39	91	51
23B-24	L	96*	49*	31	58	38	--	--
23B-45	L	91	50	30	58	37	86	45*
MINIMUM		91	47	30	57	37	86	45
MAXIMUM		102	51	32	62	40	93	51
MEAN		97	50	31	58	39	90	47

* estimates

TABLE A2.8 Norby site mature distal radii data (All measurements in mm).

SPECIMEN NUMBER		R8	R9	R10	R11	R12
8A-35	R	98	56	23	40	62
10A-2	L	94	52	20	37	62
13A-31	L	94	52	18	35	61
2B-19	L	99	53	22	38	67
4B-13	L	92	--	--	34*	61
10B-40	R	95	--	--	35	--
10B-41	L	100	--	21	36	62
10B-34	R	93	53	20	36	58
15B-28	R	96	54	20	37	61
2D-16	R	97	--	--	35	61
MINIMUM		92	52	18	34	58
MAXIMUM		100	56	23	40	67
MEAN		96	53	21	36	61

* estimates

TABLE A2.9 Norby site immature distal radii data (All measurements in mm).

SPECIMEN NUMBER		R8	R9	R10	R11	R12
1A-10	R	91	51	18	34	59
2B-17	R	88	51	17	35	67
4B-28	R	91	48	21	32	63
9B-10	L	89	51	20	36	59
17B-4	R	94	50	19	34	60
MINIMUM		88	48	17	32	59
MAXIMUM		94	51	21	36	67
MEAN		91	49	19	34	62

Tibia

Only distal tibia were studied using five measurements. Eighteen specimens (MNI = 10) were available, four of which were immature. Both an osteometric board and a sliding callipers are required.

T1 Greatest breadth of distal end (Speth 1983; Todd 1987): The distal tibia is placed on the osteometric board in a transverse position, with the cranial margins of the articular grooves positioned over the slider grooves. The medial surface of the distal end and the medial surface of the diaphysis (at the point where the tibia extends off the board) are fixed against the end of the board. The slider contacts the lateral margin of the distal end (Figure A2.5a).

T2 Greatest depth of distal end (Speth 1983; Todd 1987): The distal tibia is placed on the osteometric board in the same manner as for T1 except rotated about 90 degrees. The cranial portion of the medial surface and the diaphysis is fixed against the end of the board. The lateral side of the distal end is positioned over the slider groove. The slider is moved until is comes into contact with the caudal surfaces of articular grooves (Figure A2.5a).

T3 Greatest breadth of lateral and medial articular grooves (Speth 1983): One jaw of the callipers is placed on the medial edge of the medial articular groove while the other is placed parallel on the lateral edge of the lateral articular groove. The largest measurement is the correct one (A2.5a).

T4 Length of medial malleolus (Speth 1983): Using a callipers, the measurement is taken from the most distal extremity to the proximal margin of the tuberosity or the roughness immediately proximal to the medial malleolus (Figure A2.5b).

T5 Greatest diagonal distance from proximal margin of tuberosity of roughness immediately proximal to medial malleolus (same as in T4) to most distal extremity of sagittal prominence or spine (Figure A2.5b).

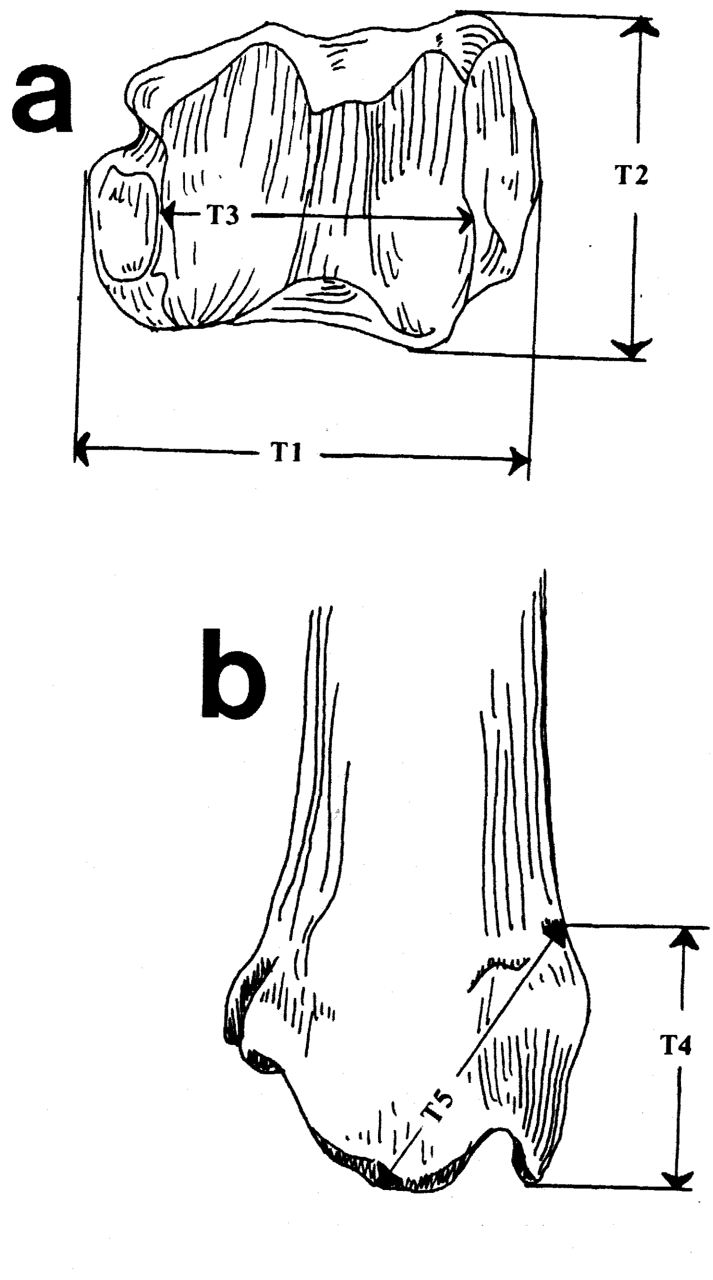


FIGURE A2.5 View of distal articulation (a) and cranial view (b) of right distal tibia (From Speth 1983).

TABLE A2.10 Norby site mature distal tibiae data (All measurements in mm).

SPECIMEN NUMBER		T1	T2	T3	T4	T5
6A-14	L	80	58	57	51	54
6A-22	R	80	58	57	53	57
7A-42	R	83	58	56	42	49
11A-36	L	77	55	55	45	53
13A-30	L	82	58	56	--	--
11B-25	R	77	56	53	46	53
11B-59	L	80	58	56	50	55
16B-77	R	81	55	54	--	54
3C-13	L	82	57	59	--	--
4C-11	L	79	57	54	55	61
4C-19	R	78	53	57	41	51
4C-27	R	73	52	51	--	--
4C-37	R	80	59	58	48	54
1D-24	R	84	58	56	--	--
MINIMUM		73	52	51	41	49
MAXIMUM		84	59	59	55	61
MEAN		80	57	56	48	55

TABLE A2.11 Norby site immature distal tibiae data. (All measurements in mm).

SPECIMEN NUMBER		T1	T2	T3	T4	T5
12A-35	R	75	52	54	43	51
6B-7	R	74	53	54	46	54
9B-19	L	76	51	54	--	--
15B-51	L	76	53	56	--	--
MINIMUM		74	51	54	43	51
MAXIMUM		76	53	56	46	54
MEAN		75	52	54	44	53

Calcaneus

A total of nineteen calcanei had two measurements taken on them. The measurement were described as follows:

C1 Transverse width of proximal end (Lorrain 1968): Using a callipers, this measurement is taken from the most medial point to the most lateral point across the "wing" of the calcaneus. The largest measurement is the correct one (Figure A2.6a).

C2 Anterior-posterior width of proximal end (Lorrain 1968): Using a callipers, this measurement is taken across the "wing" again but from the most anterior point to the most posterior point on the calcaneus. The largest measurement is again the correct one (Figure A2.6b).

TABLE A2.12 Norby site calcanei data (All measurements in mm).

SPECIMEN NUMBER		C1	C2	SPECIMEN NUMBER		C1	C2
16B-101	L	45	50	4C-48	R	45	49
4C-40	L	46	48	4C-1	L	44	49
1C-53	L	45	49	20B-37	L	44	47
1C-24	R	37	41	24B-5	R	36	42
11A-50	L	43	47	16B-80	L	44	50
11B-14	R	42	48	6A-11	R	43	48
8B-29	L	43	51	12A-29	L	40	45
12A-16	L	42	48	16B-88	R	44	50
9A-51	R	42	46	7A-12	L	47	50
7A-37	L	47	51	11A-31	L	42	46
19A-36	R	41	44	8B-12	R	45	51
14A-36	R	46	51	5A-A	L	40	45

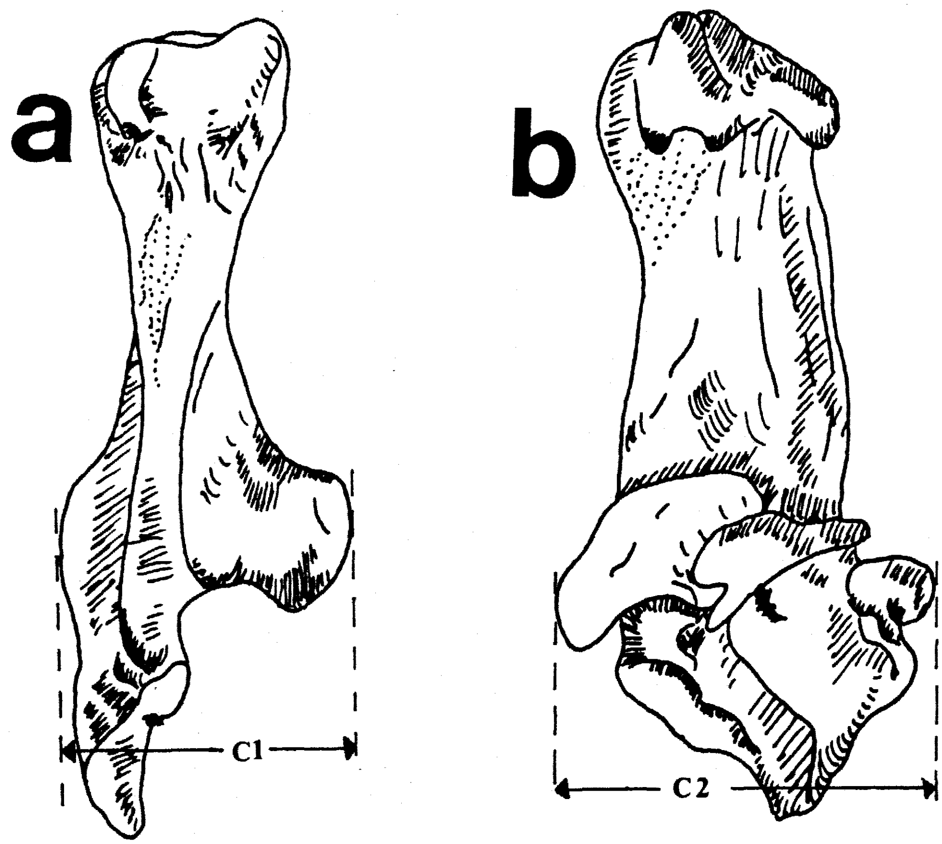


FIGURE A2.6 Caudal (a) and medial (b) views of left calcaneus (From Lorrain 1968).

Other Tarsals and Carpals

The measurements used in the analysis of carpals and tarsals are those of Morlan (1989:5-11). They have not been given a Norby site measurement code, as was the case with every other group of elements, because it proved to be rather cumbersome. Instead Morlan's length (proximal-distal dimension), width (medial-lateral dimension) and depth (anterior-posterior dimension) terminology has been retained.

A sliding calliper was used for all measurements. Measurements are presented in Tables A2.13 through A2.21.

1. Radial Carpal

Length - measured at the anterior end using the relatively flat distal surface as a reference (Figure A2.7a).

Width - measured adjacent to the distal end by placing the fixed arm of the callipers on the two distal articular facets for the internal carpal and moving the slider into contact with the medial surface (Figure A2.7b).

Depth - is the greatest anterior-posterior dimension (Figure A2.7a).

2. Internal Carpal

Length - measured near the anterior end using the unciform facet as a reference plane (Figure A2.7c).

Width - point to point measurement along the proximal border of the anterior end (Figure A2.7c).

Depth - measured perpendicular to the plane formed by the radial carpal facets near the proximal surface (Fig. A2.7d).

3. Ulnar Carpal

Anterior Length - measured from the unciform carpal facet to the highest anterior point on the ulnar facet (Figure A2.7e).

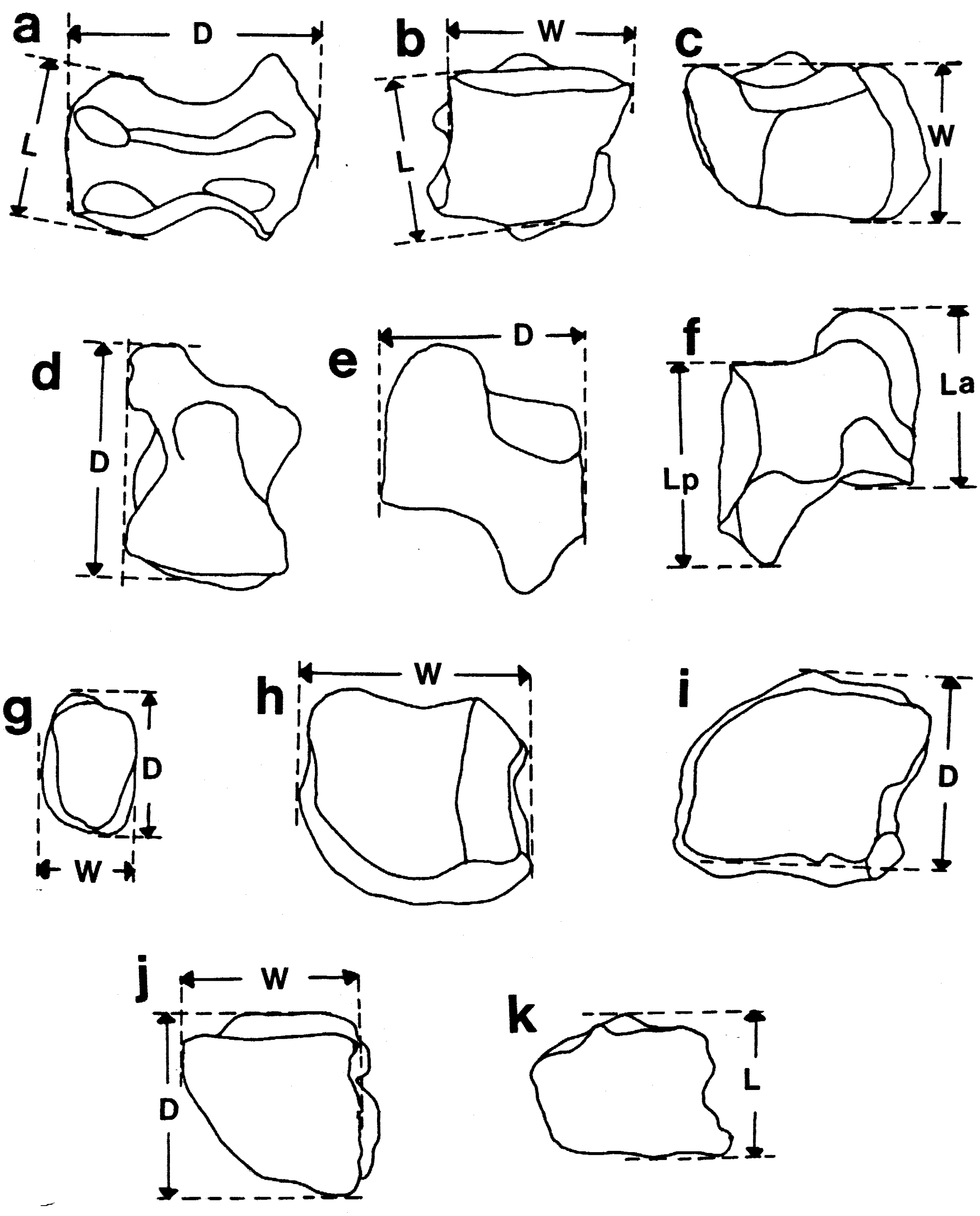


FIGURE A2.7 Length (L), width (W) and depth (D) measurements for bison carpals. Only left elements are shown here. (a,b - radial; c,d - internal; e,f - ulnar; g - accessory; h,i - fused 2/3; j,k - unciform).(From Morlan 1989).

Width - the maximum medial-lateral dimension,using the calliper to span the high points on the lateral surface (Figure A2.7f).

Depth - measured from the relatively flat accessory carpal facet to the anterior surface of the ulnar carpal (Figure A2.7f).

4. Accessory Carpal

Length - the larger dimension of the articular surface and width is the smaller dimension (Figure A2.7g).

Depth - measured perpendicular to the articular surface (Figure A2.7h).

5. Fused 2/3 Carpal

Length - the maximum proximal-distal dimension using the relatively flat distal surface as a reference plane (Figure A2.7i).

Width - measured placing the fixed arm of the callipers on the unciform carpal facets and bringing the slider into contact with the medial surface (Figure A2.7i).

Depth - measured from a plane formed by the posterior margin and is most easily visualized in the ventral view (Figure A2.7j).

6. Unciform Carpal

Length - the maximum proximal-distal dimension as found near the centre of the bone (Figure A2.7k).

Width - measured by placing the fixed arm of the calliper on the fused 2/3 carpal facets and bringing the slider into contact with the lateral surface adjacent to the distal surface (Figure A2.7l).

Depth - measured from the plane at the posterior end adjacent to the distal surface (Figure A2.7l).

7. Fused Central/4 Tarsal

Length - measured from the plane defined by the most distal extremities of fused 2/3 tarsal facet to proximal tip of the posterior-medial process (Figure A2.8a).

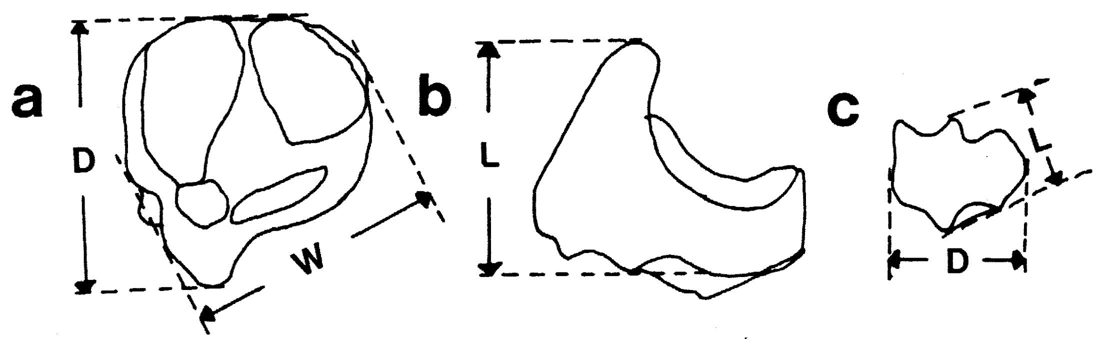


FIGURE A2.8 Length (L), width (W) and depth (D) measurements for bison tarsals. Only left elements are pictured above. (a,b - fused central/4; c - fused 2/3; d - lateral malleolus.) (From Morlan 1989).

Width - measured on the plane established by the medial surface and <u>depth</u> from the plane of the anterior surface; these measurements are <u>not</u> perpendicular to one another but are easily replicated (Figure A2.8b).

8. Fused 2/3 Tarsal

Length - smallest proximal-distal dimension, measured near the centre of the bone.

Width - measured from the plane on the lateral surface, and <u>depth</u> is the greatest point to point measurement in the anterior-posterior dimension (Figure A2.8c).

9. Lateral Malleolus

Length - measured from the plane of the calcaneus facet to the central process (Figure A2.8d).

Width - is measured at right angles to the view shown in Figure A2.8d, and <u>depth</u> is the greatest anterior-posterior measurement.

TABLE A2.13 Measurements of radial carpals from the Norby site (Measurements in mm).

SPECIMEN		LENGTH	WIDTH	DEPTH
1A-10	L	35.0	34.8	51.9
1A-39	R	35.3	35.0	53.7
3A-26	R	38.0	36.0	52.0
7A-17	L	35.2	38.0	57.0
8A-46	R	35.7	38.0	57.8
10A-4	L	34.2	32.5	54.0
12A-30	R	38.0	34.5	55.8
12A-43	R	33.8	33.5	52.3
12A-51	L	30.0	26.0	42.0
13A-68	L	33.9	33.3	54.0
15A-39	L	34.0	26.0*	44.2
15A-73	R	37.0	37.0	57.5
1B-3	L	37.4	34.6	55.5
2B-1	R	37.2	31.1	51.0
3B-14	R	37.2	35.0	58.0
4B-21	R	35.7	30.2	53.0
4B-27	L	36.5	29.7	49.0
9B-50	L	36.1	35.8	56.2
9B-12	L	36.0	32.0	54.2
10B-19	R	36.0	32.8	53.9
10B-72	L	36.1	31.4	54.9
11B-93	R	38.2	37.2	58.0
15B-39	L	37.0	30.5	50.0
15B-78	L	37.2	34.1	55.0
16B-29	R	37.0	34.8	54.1
19B-39	R	36.4	34.5	57.0
22B-44	L	34.0	34.0	57.3
23B-46	L	33.4	28.0	46.5
24B-1	R	34.5	33.2	50.1
24B-37	R	32.8	28.0	46.0
24B-19	R	32.2	30.0	46.0
25B-8	R	35.5	29.0	48.9
4C-58	R	35.0	32.7	53.7
3C-37	L	35.1	33.3	54.0
6D-28	R	36.7	33.2	52.4
3D-38	L	37.2	--	55.0
2D-22	L	34.0	36.0*	55.7
D-15	R	35.0	34.0	51.0

* estimates

TABLE A2.14 Measurements of the internal carpals from the Norby site. (Measurements are all in mm).

SPECIMEN		L	W	D	SPECIMEN		L	W	D
1A-38	R	33.0	34.1	52.3	10B-48	L	31.3	36.4	51.0
1A-34	L	32.7	36.4	51.0	10B-85	R	35.0	37.1	57.2
2A-19	R	34.2	39.0	--	10B-93	R	34.2	40.0	55.7
3A-32	L	32.0	37.0	54.9	11B-60	R	31.0	35.0	51.0
7A-31	R	31.0	36.0	54.2	12B-14	L	34.0	37.5	54.5
8A-45	R	32.2	35.5	55.0	15B-10	R	34.0	38.0	54.0
10A-3	L	29.8	37.0	51.2	16B-32	L	32.1	37.0	51.0
13A-54	L	31.0	32.1	54.0	19B-30	R	33.0	36.0	56.9
2B-12	L	32.3	35.0	56.0	1C-56	L	31.0	37.0	49.0
3B-38	R	32.0	35.3	56.6	2C-16	L	28.5	33.0	49.0
4B-5	R	34.0	37.1	51.0	3C-1	L	33.0	37.0	53.0
4B-10	L	34.0	35.0	45.0	3C-39	L	32.0	35.0	53.0
8B-1	R	33.1	39.5	53.0	2D-23	L	32.0	38.0	55.5
9B-2	L	32.5	38.0	52.0	6D-32	L	34.0	37.5	56.0
9B-14	R	33.0	37.0	53.0	25B-28	R	31.2	36.0	46.0

TABLE A2.15 Measurements of Norby site ulnar carpals. (All measurements are in mm).

SPECIMEN		La	D	SPECIMEN		La	D
1A-35	L	36.0	42.5	15B-47	R	37.0	48.6
1A-37	R	35.0	43.0	15B-52	L	35.7	44.0
2A-22	L	35.0	43.5	15B-79	L	32.2	39.6
8A-44	R	36.0	46.5	16B-3	R	33.9	44.7
10A-9	L	35.0	43.7	16B-42	R	35.0	43.0
10A-32	R	39.7	49.5	16B-56	L	37.2	48.0
12A-24	R	36.1	43.5	19B-47	R	40.5	46.5
13A-66	L	35.0	45.0	23B-57	L	36.4	43.5
1B-21	R	39.0	48.7	24B-28	R	31.0	38.0
4B-70	R	37.0	46.0	24B-118	R	31.0	41.0
8B-9	R	35.1	45.1	25B-48	L	36.0	47.9
9B-3	L	35.5	47.9	3C-6	R	32.1	40.0
9B-18	L	35.1	41.2	3C-41	L	36.0	45.0
10B-37	R	35.1	42.3	2D-11	R	36.2	44.5
15B-6	L	38.6	49.1	2D-17	R	36.9	49.2

TABLE A2.16 Measurements of the Norby accessory carpals. (Measurements are in mm).

SPECIMEN	L	W	D	SPECIMEN	L	W	D
1A-25	29.0	16.5	--	11B-92	26.2	15.0	31.8
3A-19	30.3	20.5	40.0	15B-5	30.7	19.0	38.5
4A-31	26.2	16.5	33.2	15B-74	29.6	20.2	39.6
5A-12	25.4	17.8	37.0	16B-31	32.1	19.9	40.5
8A-52	31.0	16.6	36.8	20B-56	30.2	20.0	37.3
8A-64	29.6	16.0	36.4	22B-47	25.0	18.2	34.9
12A-53	27.8	20.0	36.1	25B-15	28.0	18.2	36.4
1B-4	32.0	17.3	39.4	2C-13	26.2	18.8	--
2B-14	31.1	18.9	38.0	3C-36	27.8	17.0	35.0
2B-20	29.8	19.0	38.5	1D-28	25.4	16.1	33.0
7B-29	27.2	16.0	30.2	6D-3	30.0	19.0	36.0
10B-13	24.7	17.0	33.5	6D-13	24.3	18.0	34.7

TABLE A2.17 Measurements of fused 2/3 carpals from the Norby site. (Measurements in mm).

SPECIMEN		W	D	SPECIMEN		W	D
1A-40	L	46.1	42.4	10B-40	R	46.1	45.3
1A-6	R	45.5	42.3	10B-55	R	45.7	42.3
3A-16	L	50.8	48.1	11B-36	L	44.0	39.2
8A-48	L	47.5	46.5	11B-69	L	49.0	43.6
13A-58	R	47.0	43.8	12B-12	L	46.0	40.5
13A-37	L	47.0	43.1	15B-48	L	49.6	45.5
15A-38	R	48.8	44.7	15B-59	R	50.0	44.5
15A-55	R	43.0	39.0	16B-67	L	41.2	40.2
2B-9	L	46.9	43.3	16B-63	L	41.7	37.3
3B-11	R	47.1	42.9	20B-59	L	49.0	48.0
3B-35	R	46.0	42.5	21B-27	L	49.0	45.8
4B-25	R	43.0	39.0	24B-89	L	40.0	37.7
4B-29	L	44.5	38.0	3C-38	R	47.5	42.5
5B-4	L	46.0	43.0	3D-33	R	49.2	45.1
9B-5	L	44.1	43.4	6D-9	R	48.3	43.3
10B-36	L	46.0	44.0				

TABLE A2.18 Measurements of the Norby site unciform carpals. (All measurements are in mm).

SPECIMEN		L	W	D	SPECIMEN		L	W	D
A-8	L	27.0	29.0	36.0	10B-81	L	31.9	40.0	35.0
1A-41	R	31.5	35.2	39.0	10B-86	R	32.2	39.6	42.5
2A-8	L	27.0	34.1	37.7	11B-89	R	29.1	34.5	42.1
2A-17	R	31.0	37.0*	41.8	12B-40	R	33.1	37.0	42.0
2A-32	R	31.0	36.0	41.0	14B-30	L	32.4	37.0	40.1
7A-30	L	31.0	36.7	43.0	16B-50	L	32.0	36.9	39.0
8A-47	R	29.1	34.7	41.0	16B-65	L	29.6	32.1	36.1
11A-27	L	31.0	36.0	41.0	15B-44	R	33.0	37.0	41.0
11A-69	R	29.1	34.0	39.9	21B-38	R	30.8	38.0	43.0
13A-70	L	29.6	35.0	40.0	24B-27	R	27.1	31.0	35.0
14A-60	R	31.5	38.5	42.0	24B-39	R	28.6	35.0	37.0
2B-5	R	27.5	32.0	--	24B-50	R	27.0	34.1	37.7
2B-11	R	31.0	34.0	40.0	3C-40	L	31.0	35.0	39.1
3B-21	L	29.3	35.0	40.0	3C-46	L	27.3	33.0	38.0
4B-12	R	29.6	31.5	42.0	4C-44	L	32.0	37.0	40.2
4B-26	L	29.0	35.0	34.6	4C-61	R	28.8	33.6	40.0
5B-5	R	30.0	35.0	39.2	2D-26	L	30.3	35.5	42.5
6B-44	L	29.0	36.1	40.9	6D-23	R	30.4	35.5	38.6
9B-16	L	31.0	35.5	42.0					

*estimate

TABLE A2.19 Measurements of the fused central/4th tarsals from the Norby site.

SPECIMEN		W	D	SPECIMEN		W	D
3A-7	L	65.0	61.5	8B-29	R	70.6	65.5
5A-7	L	69.0	66.5	11B-35	L	71.0	69.0
6A-19	R	72.0	66.0	11B-53	R	72.0	67.2
6A-27	L	71.5	65.5	11B-49	L	63.0	64.0
6A-42	L	65.0	68.0	15B-58	L	66.0	64.0
6A-54	R	68.0	66.5	16B-22	L	57.0	57.0
7A-39	R	73.4	71.0	16B-87	R	70.5	67.0
8A-39	L	69.0	64.5	16B-97	R	69.0	66.0
9A-11	R	64.0	65.0	16B-103	L	69.0	66.0
11A-12	R	73.3	69.3	17B-61	L	61.0	64.0
11A-75	L	63.9	64.0	20B-38	R	68.5	68.0
12A-49	R	67.0	68.0	24B-18	L	70.3	66.5
13A-78	R	68.5	67.0	25B-40	L	62.5	59.0
13A-43	R	73.0	68.0	25B-45	L	66.8	66.0
12A-38	L	70.5	69.0	25B-54	R	67.2	66.0
15A-61	R	69.0	66.0	1C-26	L	70.0	63.0*
15A-63	R	59.7	58.0	1C-37	R	73.3	69.2
1B-11	R	67.5	66.0	3C-12	R	74.0	68.0
4B-42	L	68.2	67.2	3C-31	R	67.0	67.0
6B-34	R	60.0	61.0	4C-27	L	67.0	68.0
8B-7	L	68.0	65.8	1D-9	L	69.0	69.5

TABLE A2.20 Measurements of Fused 2/3 tarsals from the Norby site. (Measurements are all in mm).

SPECIMEN		W	D	SPECIMEN		W	D
1A-2	L	31.0	49.2	11B-70	R	29.1	46.7
4A-30	R	27.0	47.0	16B-20	R	25.0	39.5
5A-8	L	28.0	45.0	16B-76	R	26.1	40.1
5A-31	R	27.3	44.3	16B-112	L	26.4	44.2
6A-43	L	29.0	46.0	18B-6	R	30.4	48.2
6A-56	L	27.4	47.9	19B-99	R	28.0	45.4
7A-38	R	30.6	46.0	20B-77	R	29.0	46.0
9A-12	R	26.8	42.9	24B-20	L	25.2	43.1
10A-38	L	26.0	43.0	25B-66	R	26.3	43.0
11A-8	R	27.0	45.0	25B-74	R	28.0	44.7
13A-44	R	32.1	47.2	1C-25	R	31.0	46.0
15A-51	L	30.0	47.7	1C-54	R	31.0	49.5
3B-36	L	31.0	47.0	3C-10	L	29.3	47.0
6B-14	L	30.0	45.0	4C-49	L	29.0	44.0
8B-38	R	29.0	46.3	6D-8	R	29.6	48.1
11B-22	L	27.0	41.1				

TABLE A2.21 Measurements of the lateral malleoli from the Norby site. (All measurements are in mm).

SPECIMEN		L	W	D	SPECIMEN		L	W	D
A-9	R	29.1	29.8	45.0	11B-58	R	32.7	33.0	44.8
4A-19	L	32.0	32.1	40.7	12B-4	L	28.8	30.9	40.3
6A-25	R	31.7	31.8	41.1	14B-33	L	33.0	33.4	43.5
7A-43	L	28.7	30.6	39.7	16B-70	R	31.3	32.2	44.0
9A-44	L	29.0	29.0	39.8	24B-10	L	27.3	27.2	35.6
11A-47	L	26.5	29.0	38.0	24B-78	L	27.4	27.5	38.8
11A-58	R	28.6	29.1	40.0	24B-112	R	27.1	28.0	38.3
12A-2	L	34.0	36.0	44.0	25B-13	R	29.8	31.0	38.2
12A-52	L	28.8	30.0	47.0	1C-35	R	34.2	48.2	36.0
14A-59	L	31.7	34.0	45.5	1D-21	L	30.4	31.9	45.4
3B-34	L	30.9	33.0	41.5	6D-43	R	30.3	30.6	39.8
6B-1	L	30.0	30.5	41.0					

Phalanges

All the measurements described below are as the were found in Roberts (1982). In total, only five measurements were taken. They were as follows:

P1 Greatest length: The diagonal measurement is taken from the most volar and medial portion of the proximal articulation to the most dorsal portion of the distal articulation. The volar proximal portion is against the rigid arm of the callipers and the distal anterior portion is moved in a slow arc to achieve the greatest length (Figure A2.9a)

P2 Length: The length is taken on the lateral portion of the phalanx (opposite that taken in the P1 measurement). The bone is placed with the lateral half of the proximal articular surface against the immoveable arm of the callipers. The moveable arm is slid to touch the most distal articular surface (Figure A2.9a)

P3 Proximal width: The phalanx is placed on a glass platform at eye level, with both mid-body volar muscle attachments touching the glass and the full width of the proximal end between the calliper arms. The proximal width is taken at the proximal end from the medial surface to the lateral surface. Main axis of the bone should be perpendicular to the callipers (Figure A2.9b).

P4 Distal width: This measurement is the maximum medial-lateral distance between the edges of the distal articulation taken to touch the slight peripheral projection. The volar surface of the phalanx is placed on the table with the distal end toward the measurer and the callipers perpendicular to the axis of the specimen. Both the medial and lateral edges of the distal end must be touching the table (Figure A2.9b).

P5 Distal height: This is the anterior-posterior height of the articulation of the distal end. The bone is placed in the same position as for measurement P4. The calliper is moved to measure from under the glass platform to the most dorsal portion of the distal articular surface. The thickness of the glass is subtracted and the bone measurement recorded (Figure A2.9a).

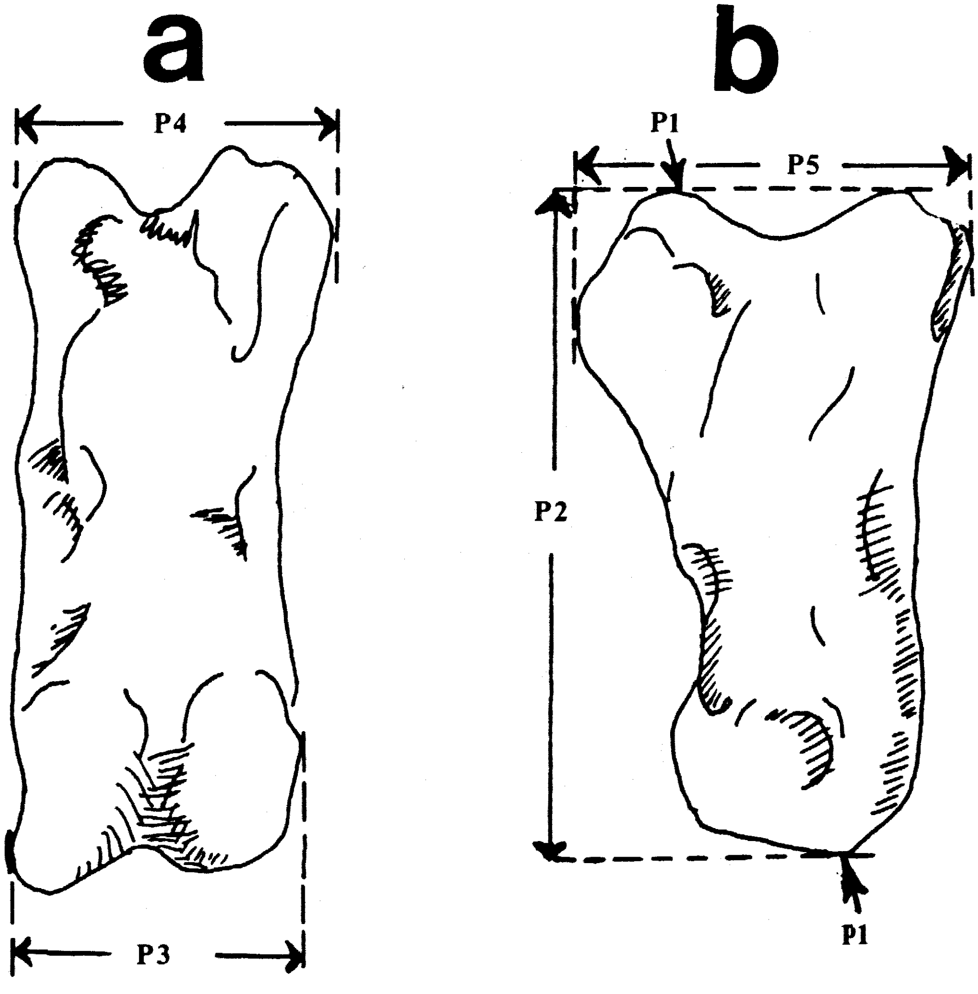


FIGURE A2.9 Ventral (a) and medial (b) views of a bison first anterior phalanx (From Lorrain 1968).

TABLE A2.22 Norby site phalanges data (All measurements are in mm).

SPECIMEN NUMBER	P1	P2	P3	P4	P5	INDEX P3/P1*100	FUNCTION
6A-30	72.8	70.8	42.4	40.7	32.6	58.24	34.87
8A-43	72.9	70.0	39.7	36.7	27.1	54.46	32.15
4An-9	72.4	67.6	39.1	37.0	26.9	54.01	32.48
11A-14	73.0	71.7	40.4	39.5	30.2	55.34	33.39
8A-17	75.0	71.6	43.6	38.2	29.2	58.37	33.76
9A-32	70.0	72.2	41.1	40.5	28.4	54.80	33.30
1A-1	67.5	68.1	38.0	36.9	27.3	54.29	31.31
8A-61	72.8	64.3	40.6	40.0	29.0	60.15	32.05
13A-62	70.0	70.0	40.0	37.0	27.7	54.95	32.42
7A-19	74.1	68.9	40.8	36.2	28.5	58.29	31.73
4A-10	75.5	73.5	44.1	40.2	27.4	59.51	31.90
2A-20	73.0	72.5	40.1	38.5	27.5	53.11	32.98
3A-13	68.7	72.1	43.0	41.1	31.9	58.90	34.20
3A-17	74.0	65.0	39.6	39.3	28.4	57.64	32.14
13A-29	74.2	70.7	42.1	41.5	31.2	55.64	34.75
11A-26	78.4	69.7	38.1	36.2	26.6	51.35	32.64
8A-42	76.1	76.0	44.2	41.3	31.4	56.38	35.59
15A-46	75.0	72.1	41.2	38.0	28.9	54.14	34.18
8A-14	73.5	73.0	40.5	38.9	27.4	54.00	32.52
7A-45	71.8	71.2	43.5	44.3	31.0	59.18	34.34
3A-20	75.4	69.8	41.4	39.7	28.3	57.66	35.00
9B-15	79.0	72.7	44.5	40.8	31.2	59.02	35.65
6B-26	70.0	74.7	42.0	40.0	30.2	53.16	30.41
3B-37	73.6	69.1	41.0	37.1	26.2	58.67	33.75
10B-6	78.1	71.0	40.0	39.0	29.9	54.35	36.43
5B-19	72.0	74.1	43.4	38.0	32.2	55.57	32.31
2B-6	75.0	68.6	35.7	36.0	27.5	50.00	32.22
16B-19	72.0	73.1	39.5	37.5	26.9	52.67	32.91
24B-94	79.0	71.0	39.1	39.9	29.9	54.31	33.23
16B-95	72.9	70.1	42.5	40.0	30.0	59.03	35.54
15B-30	68.5	75.0	43.0	38.0	30.2	54.43	33.34
3B-24	72.7	69.3	39.0	38.8	28.9	53.50	32.26
10B-20	69.2	66.1	38.6	40.5	29.4	56.34	34.12
10B-33	77.0	70.2	42.7	35.5	31.0	58.73	30.11
15B-25	71.6	67.6	36.8	38.7	25.6	53.18	35.13

TABLE A2.22 (cont.)

SPECIMEN NUMBER	P1	P2	P3	P4	P5	INDEX P3/P1*100	FUNCTION
20B-45	71.0	66.7	39.5	36.5	28.7	57.83	31.95
23B-23	72.7	74.5	40.0	36.0	26.4	51.58	32.79
15B-37	69.0	76.0	44.1	37.8	31.1	57.27	32.23
9B-28	75.1	70.0	38.7	36.8	28.5	54.05	31.33
16B-73	71.5	67.0	36.2	37.8	27.7	52.46	32.59
4B-24	78.9	72.0	39.9	41.0	26.9	53.13	32.70
9B-36	68.3	70.1	41.3	39.4	29.5	57.76	35.87
2B-13	75.8	74.1	43.7	36.3	30.4	55.39	31.60
6B-22	73.5	68.9	42.6	40.1	29.5	56.83	34.34
10B-24	71.0	68.6	38.6	39.0	30.5	58.60	33.34
5B-9	72.0	71.1	41.8	41.5	29.3	52.52	34.13
9B-11	74.0	69.0	40.0	36.1	32.0	58.87	32.59
10B-74	69.9	69.7	37.7	34.3	28.6	55.56	30.75
17B-18	72.0	72.6	40.6	37.4	24.9	50.95	31.75
20B-50	74.3	68.1	38.1	37.6	28.2	58.08	32.42
12B-18	71.9	68.6	41.0	39.1	27.7	52.92	34.01
17B-19	71.0	70.4	42.6	40.6	29.4	55.18	33.85
16B-13	79.0	69.7	42.2	43.2	31.0	59.25	34.52
10B-67	70.9	69.5	42.5	39.2	33.0	59.72	35.83
9B-45	71.0	74.4	40.1	38.2	30.4	53.80	32.66
20B-20	74.5	69.0	41.6	38.0	29.4	56.56	32.51
3C-4	78.1	69.5	38.4	36.0	29.3	58.59	31.97
4C-20	70.0	72.3	40.4	38.9	26.5	51.34	33.60
4C-13	73.0	73.9	39.2	39.5	26.9	51.73	31.95
3C-7	72.7	70.0	38.2	35.6	29.5	56.00	31.56
2D-24	72.4	69.2	41.7	38.9	25.5	52.33	33.52
1D-11	70.0	70.0	38.0	35.0	29.8	57.36	31.84
3D-19	69.8	69.6	41.0	40.9	26.8	52.49	33.47
1D-23	71.0	66.5	41.5	39.0	30.4	58.57	32.93
2D-10	72.6	68.0	40.2	38.1	30.4	59.46	33.05

B. BIVARIATE CHARTS FOR LONG BONE MEASUREMENTS

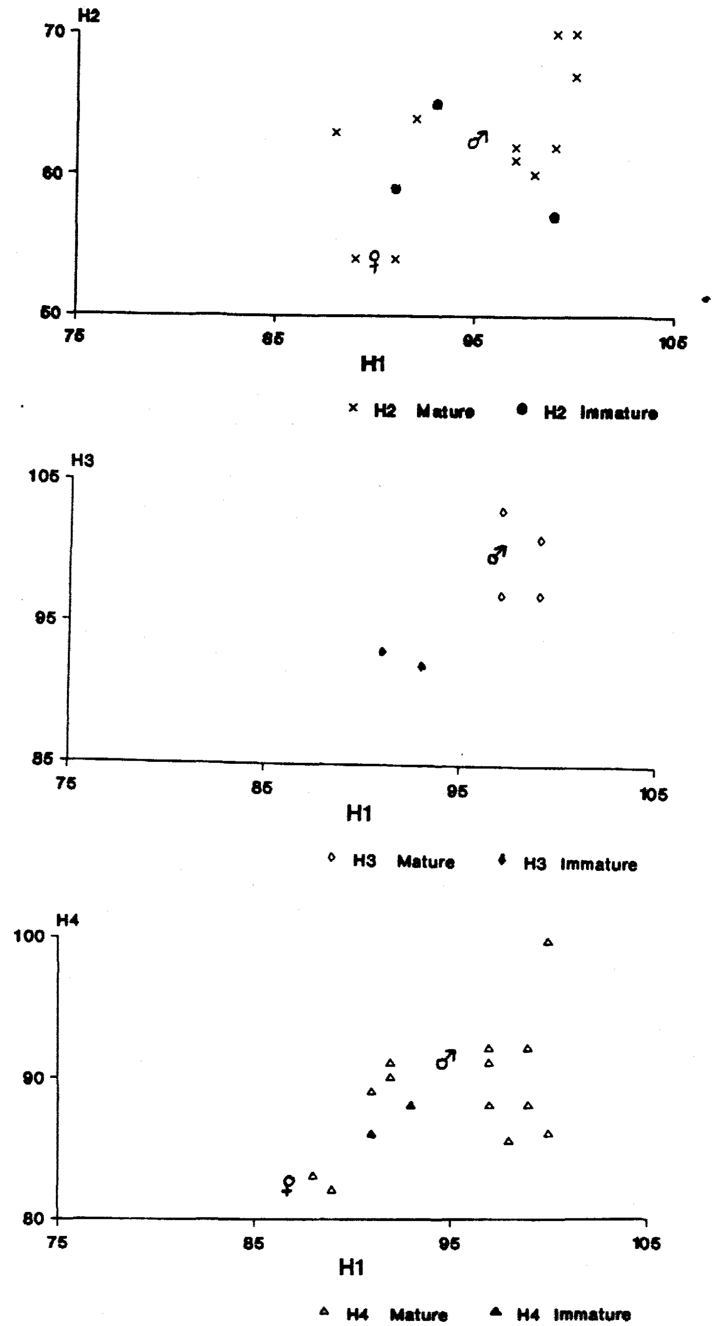


FIGURE A2.10 Bivariate scatters for measurements of Norby site humeri.

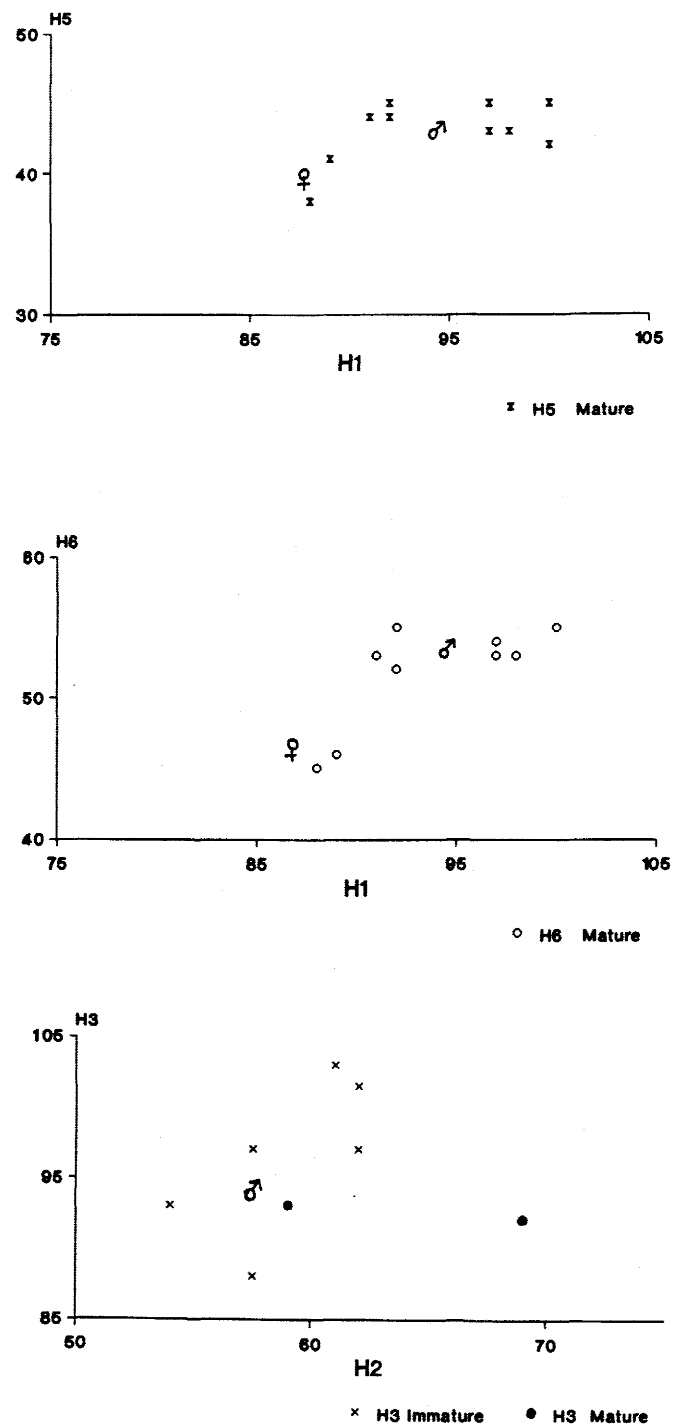


FIGURE A2.11 Bivariate scatters for Norby site humeri .

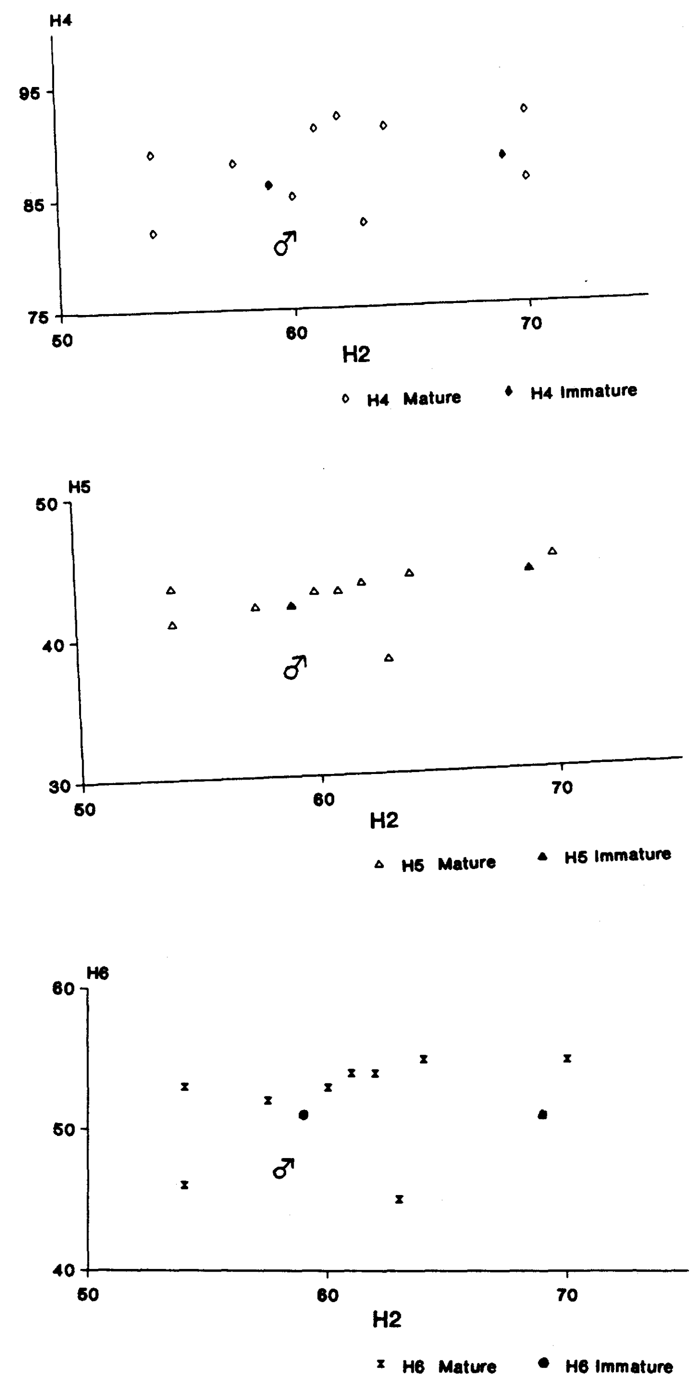


FIGURE A2.12 Bivariate scatters for Norby site humeri.

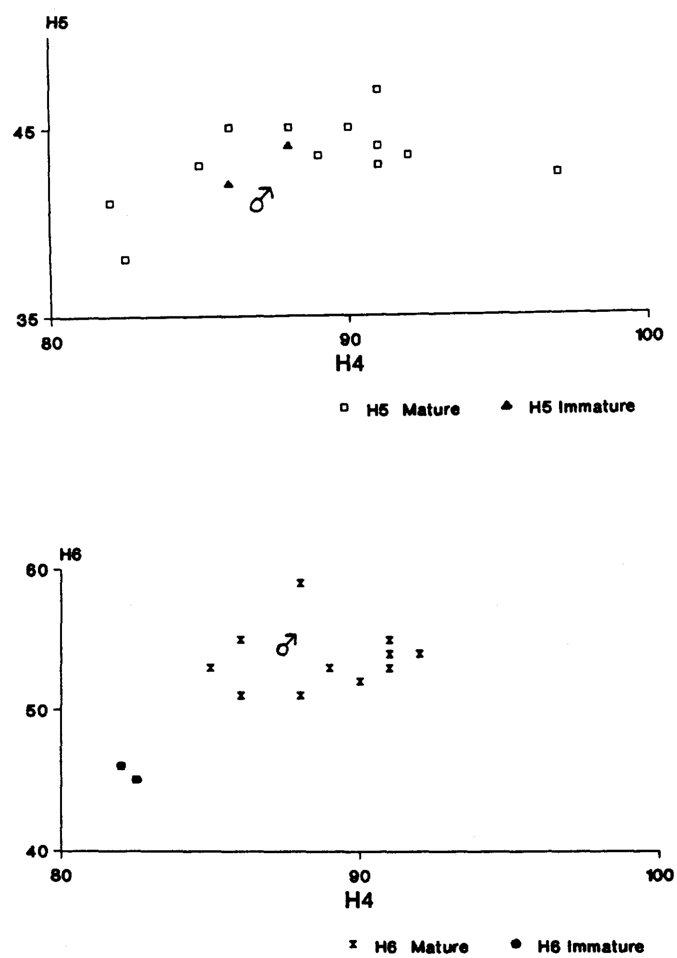


FIGURE A2.13 Bivariate scatters for Norby site humeri.

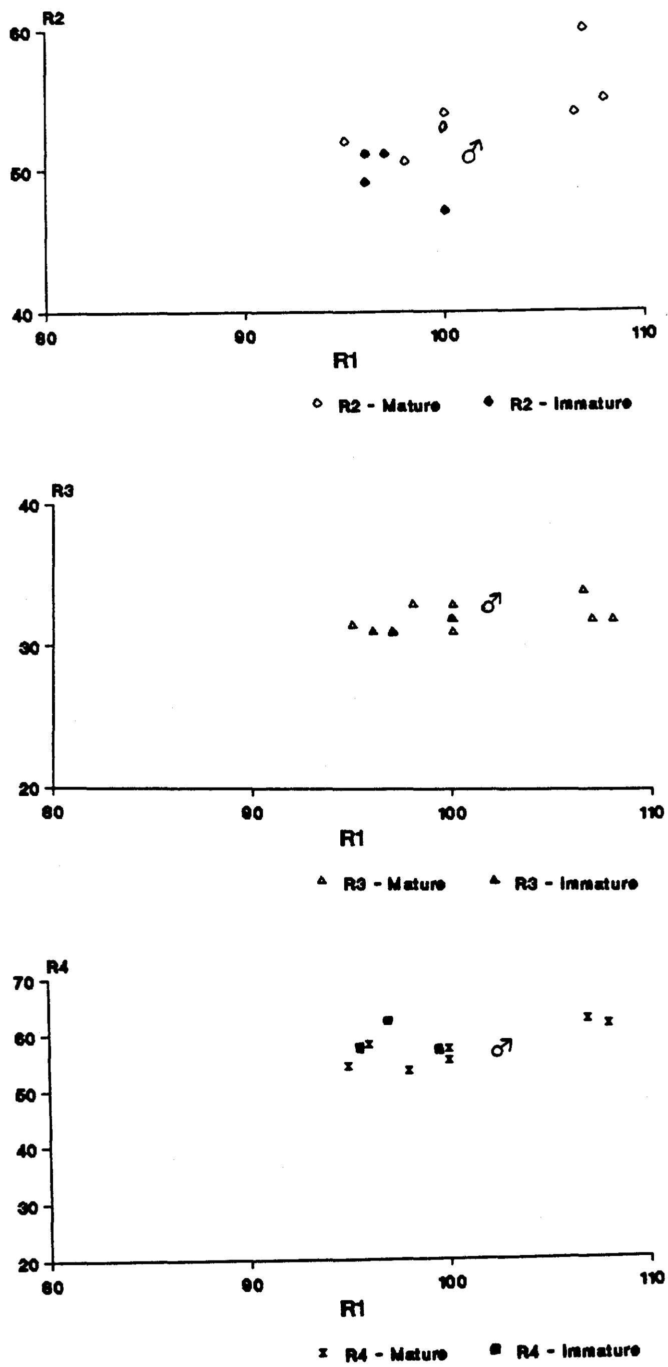


FIGURE A2.14 Bivariate scatters for Norby site proximal radii.

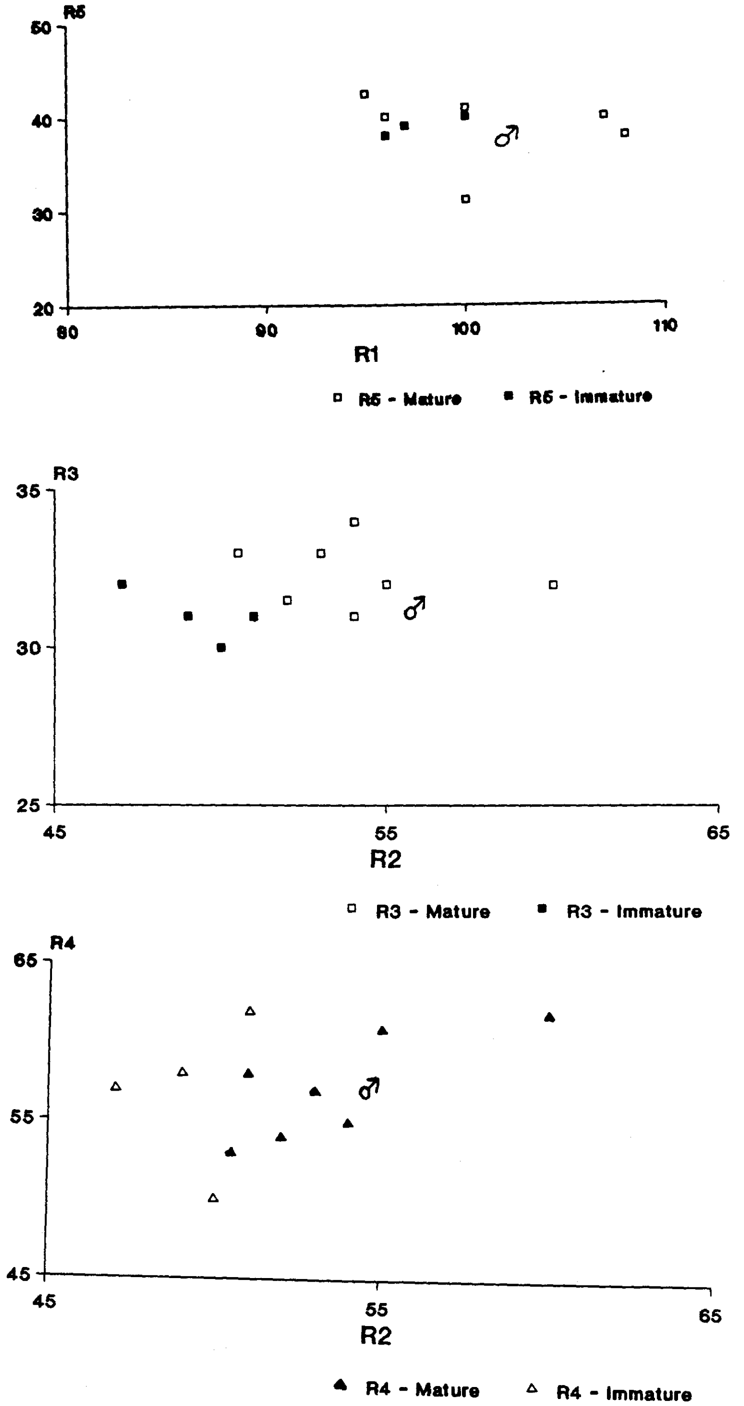


FIGURE A2.15 Bivariate scatters for Norby site proximal radii.

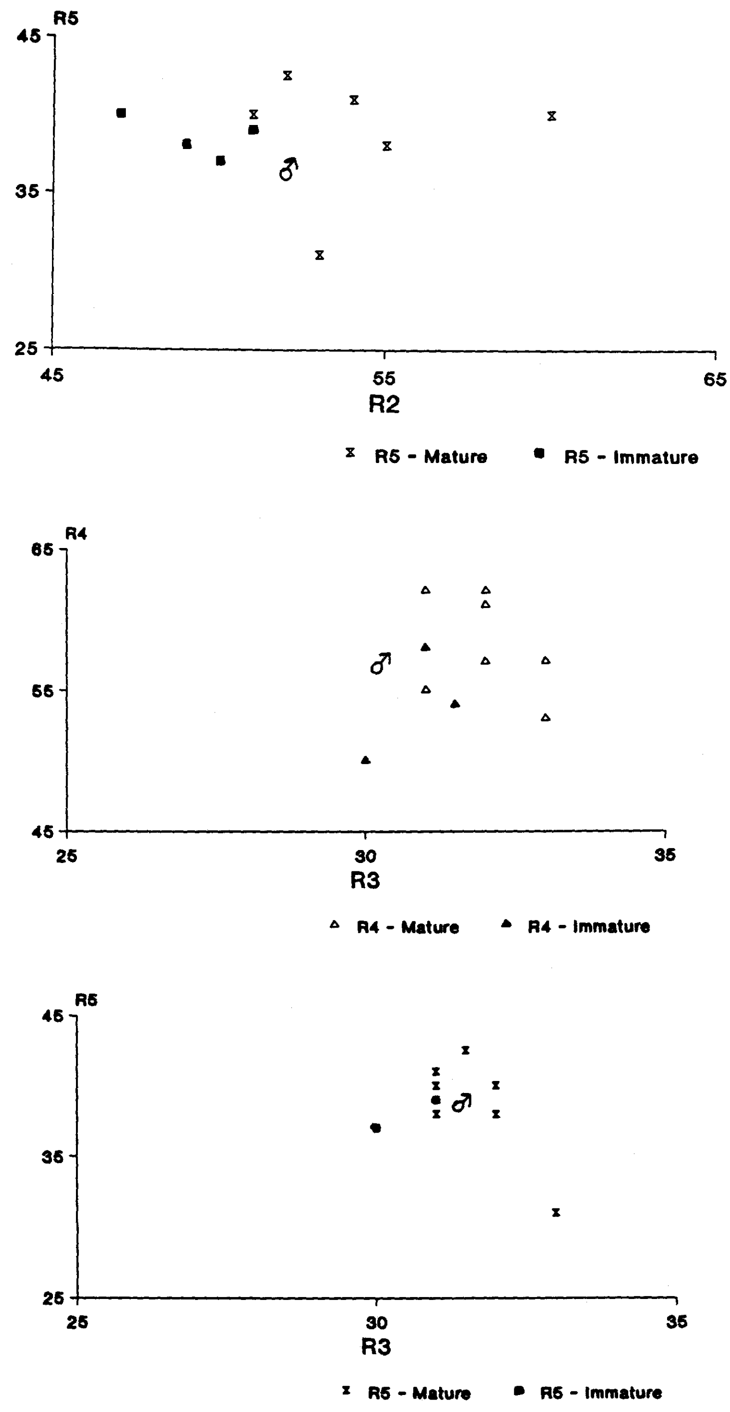


FIGURE A2.16 Bivariate scatters for Norby site proximal radii.

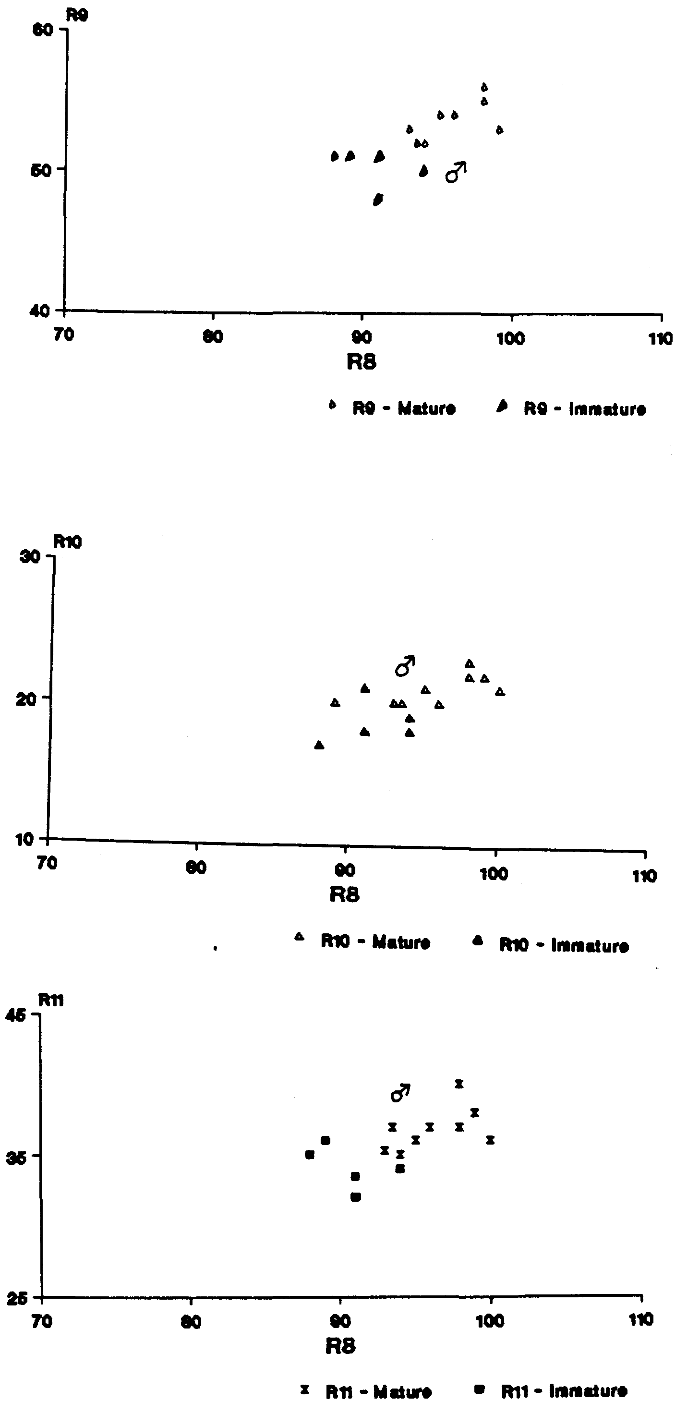
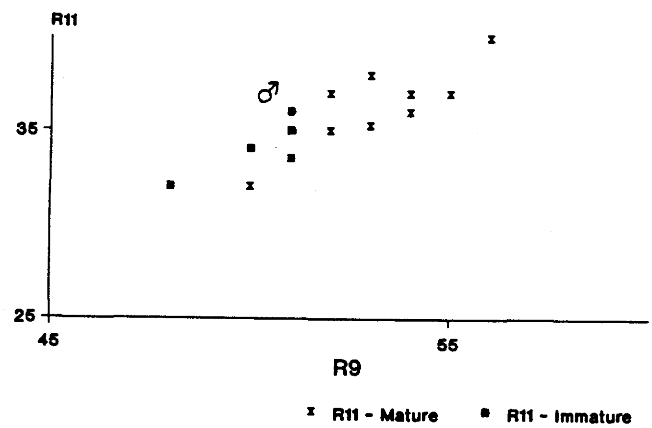


FIGURE A2.17 Bivariate scatters for Norby site distal radii.



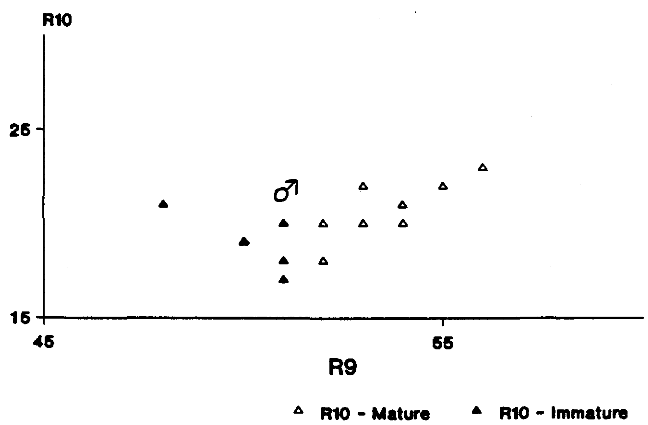


FIGURE A2.18 Bivariate scatters for Norby site distal radii.

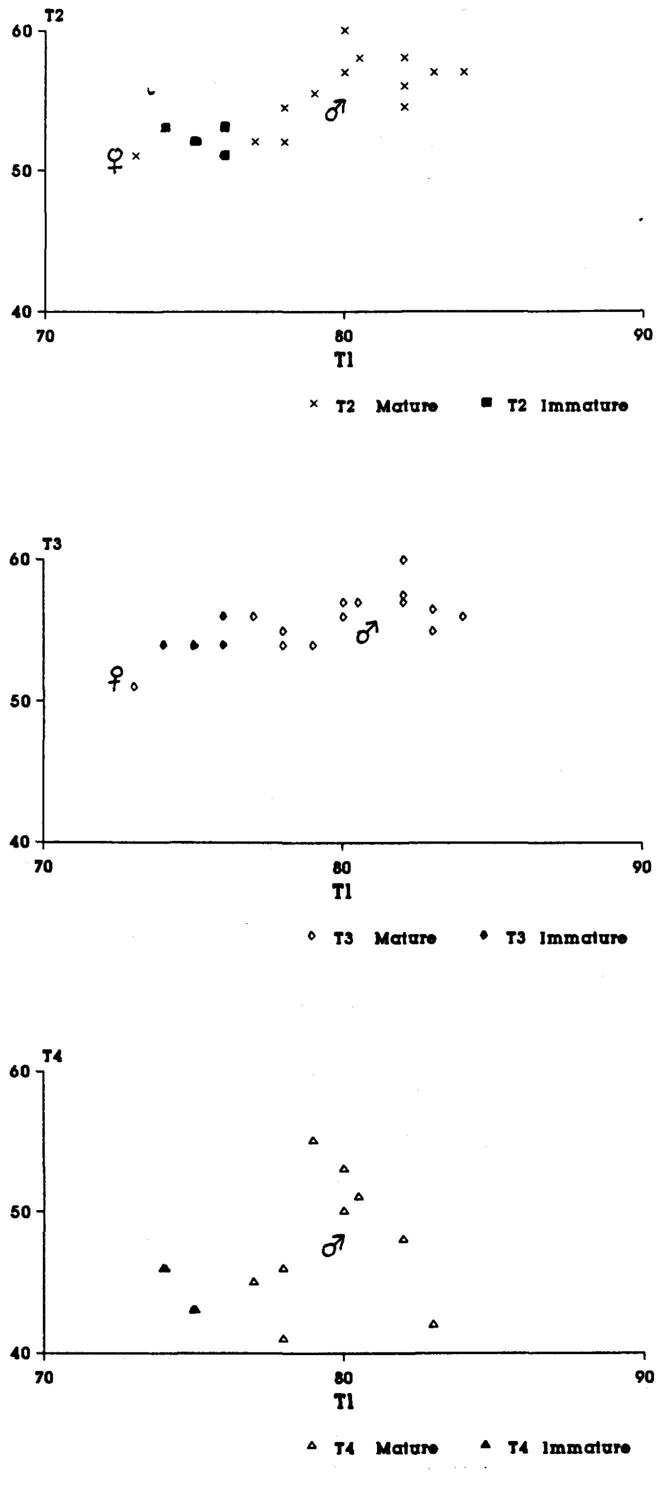


FIGURE A2.19 Bivariate scatters for Norby site distal tibiae.

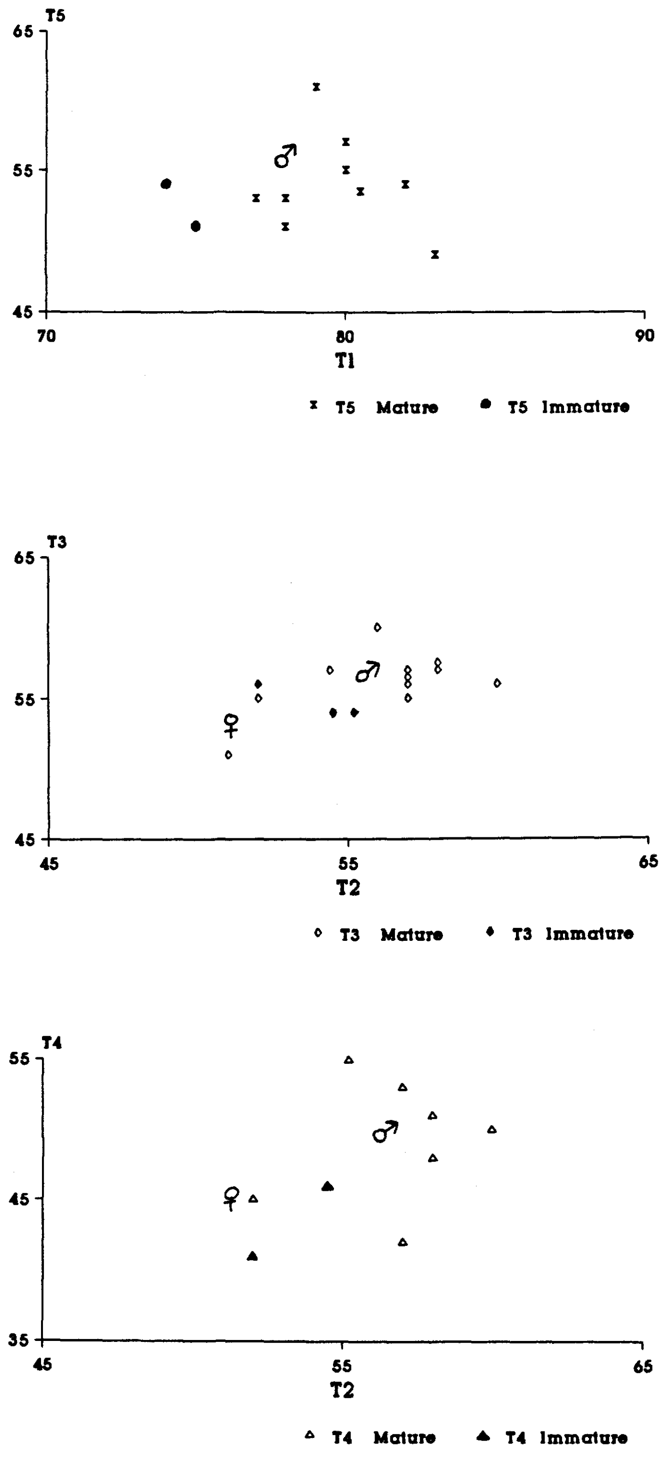


FIGURE A2.20 Bivariate scatters for Norby site distal tibiae.

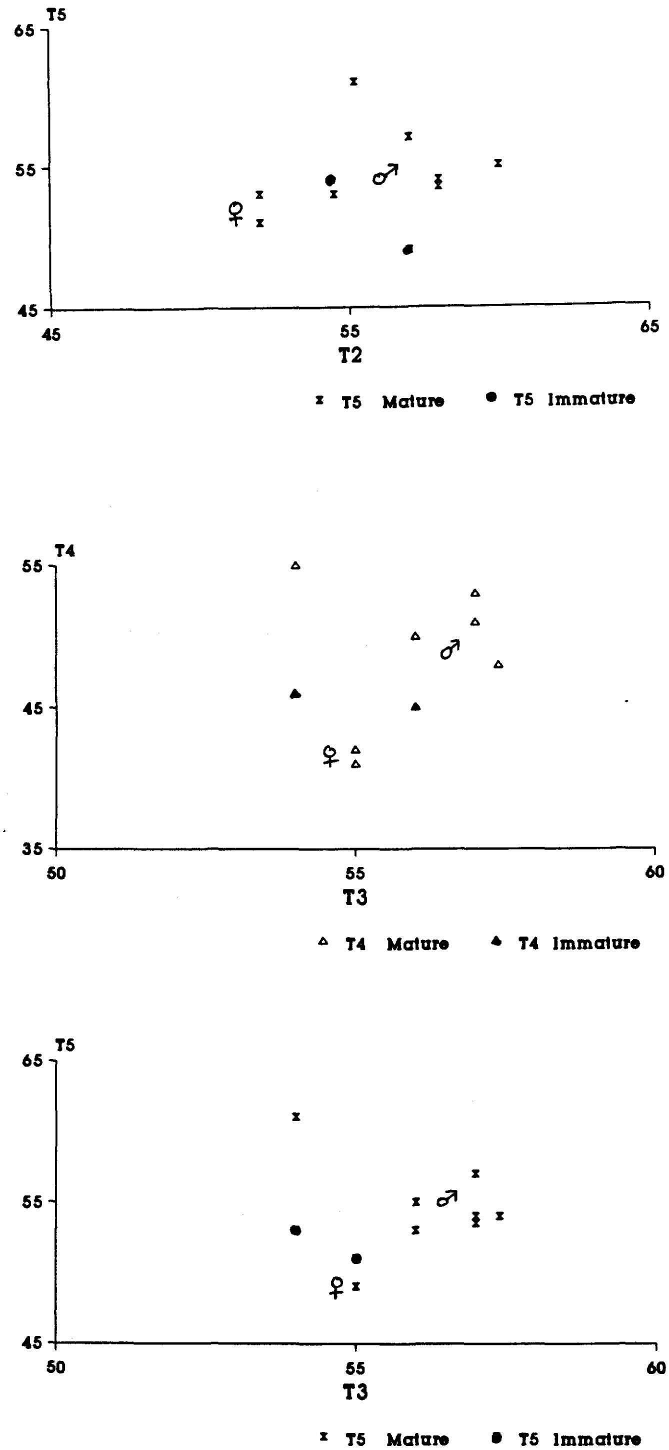


FIGURE A2.21 Bivariate scatters for Norby site distal tibiae.

C. BIVARIATE CHARTS FOR CARPAL AND TARSAL MEASUREMENTS

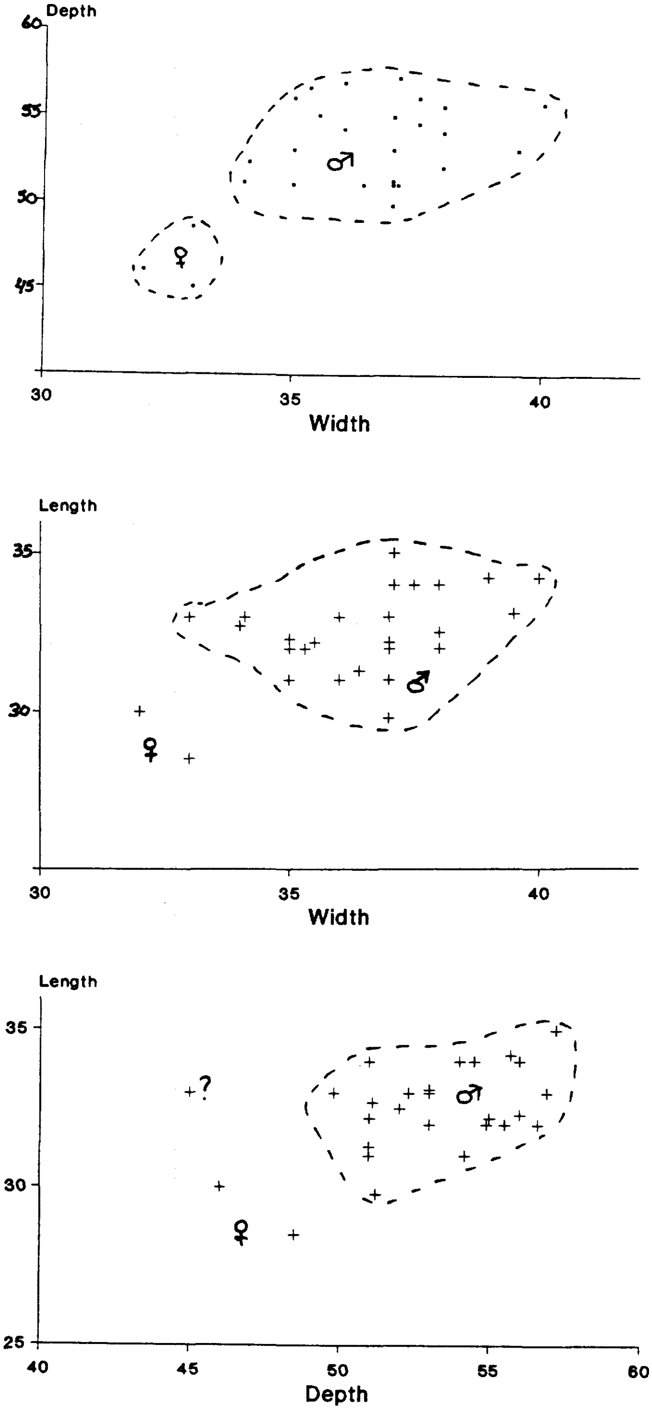


FIGURE A2.22 Bivariate scatters for Norby site internal carpals.

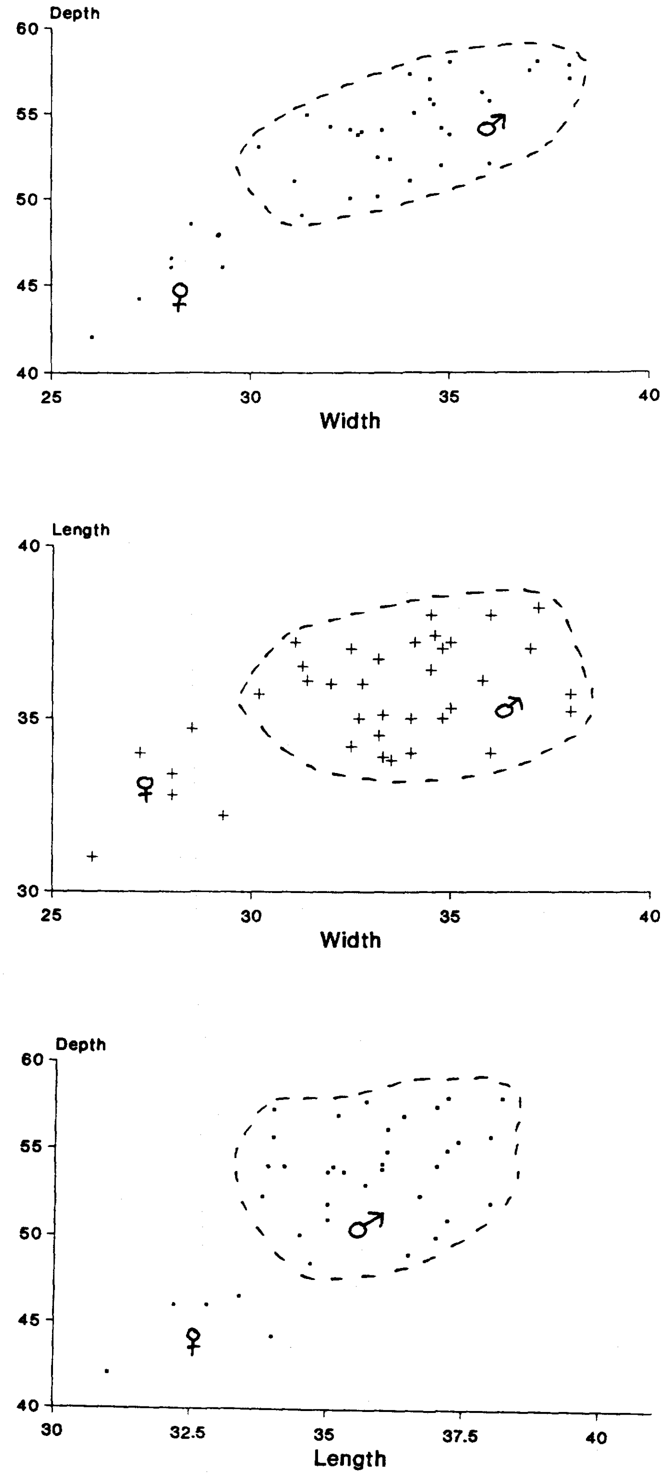


FIGURE A2.23 Bivariate scatters for Norby site radial carpals.

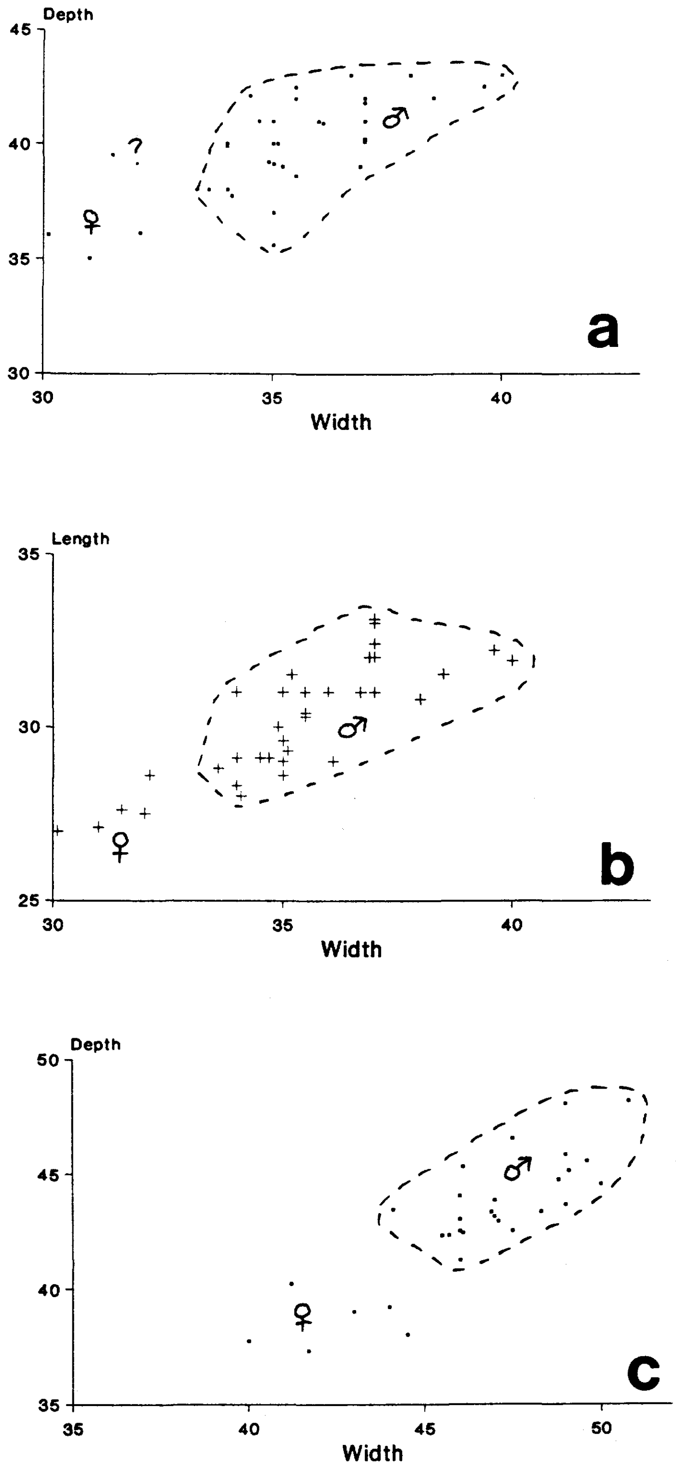


FIGURE A2.24 Bivariate scatters of unciform (a,b) and fused second and third carpals (c) from the Norby site.

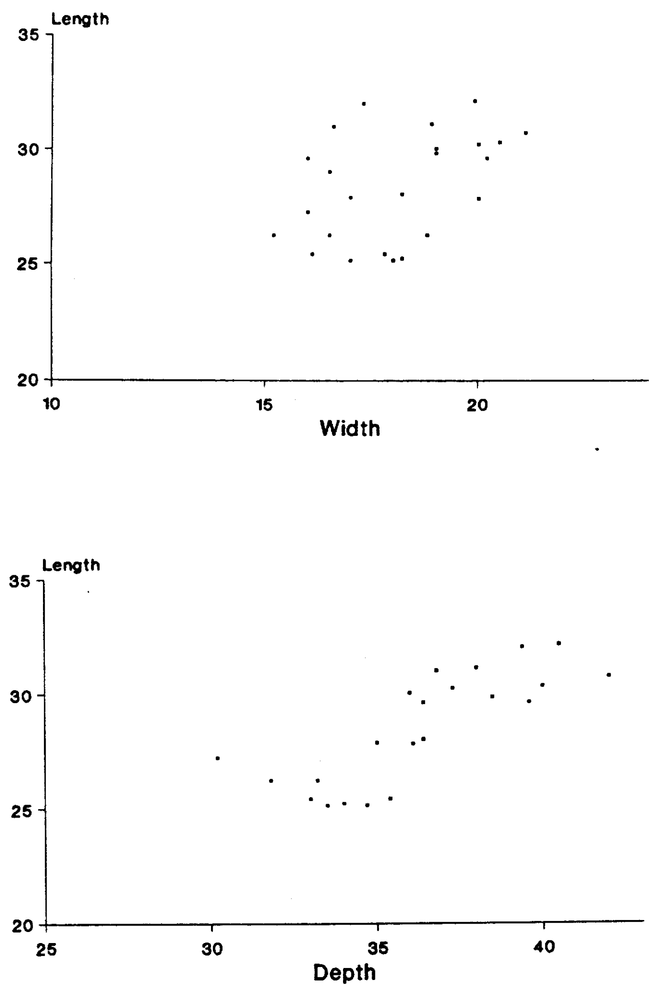


FIGURE A2.25 Bivariate scatters of data for accessory carpals from the Norby site.

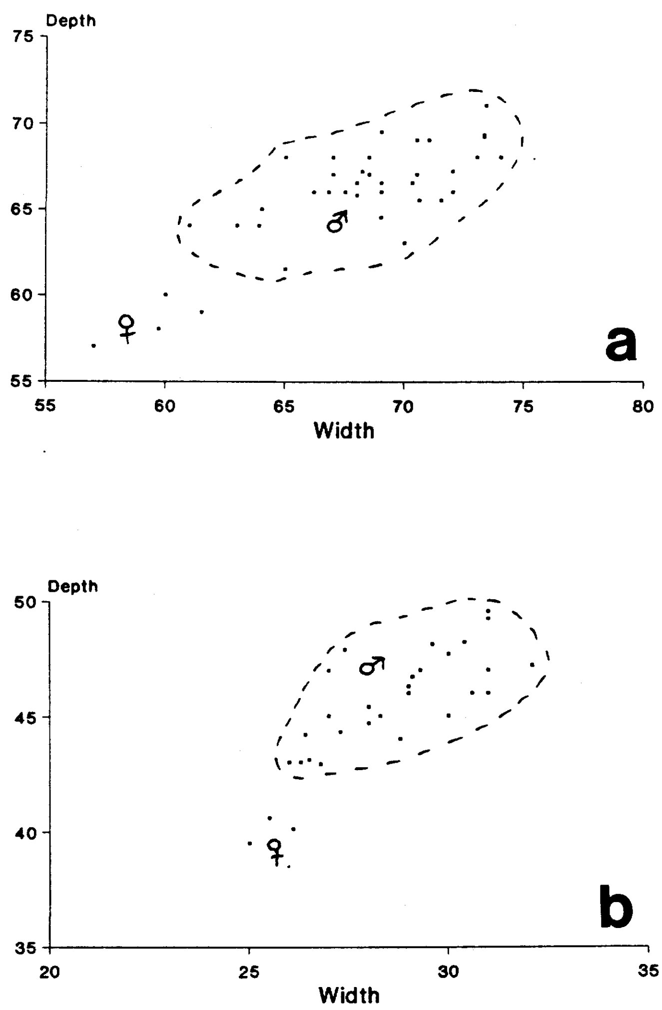


FIGURE A2.26 Bivariate scatters for the fused central and fourth (a) and fused second and third (b) tarsals from the Norby site.

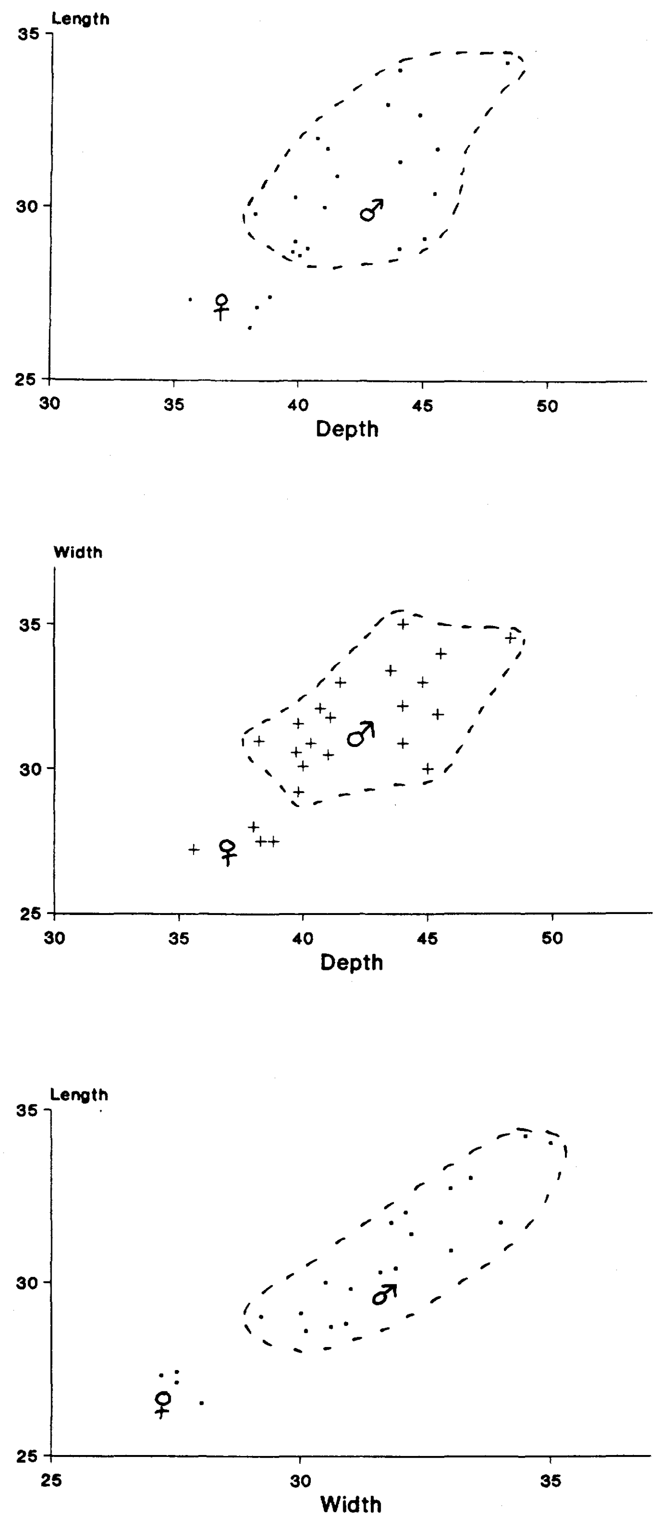


FIGURE A2.27 Bivariate scatters for lateral malleoli from the Norby site.